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J. B. Stetser and R. H. Norton, "Combustion Train for Carbon Determination," *The Iron Age, Vol. 102, No. 8 (Aug. 22, 1918).*
J. B. Stetser, "Ascarite," *Chemistry and Industry (London), Vol. 43, No. 25 (June 20, 1924), p. 637.*
A.S.T.M. (American Society for Testing Materials), "Methods for Chemical Analysis of Metals," *1950, p. 6.*
Fritz Pregl, "Quantitative Organische Mikroanalyse," *5th ed. edited by H. Roth (Vienna, 1947), p. 18;* and *5th English ed., revised and edited by Julius Grant (Philadelphia, 1951), p. 50.*
Al. Steyermark, "Quantitative Organic Microanalysis," *(Philadelphia, 1951), p. 84, ff.*

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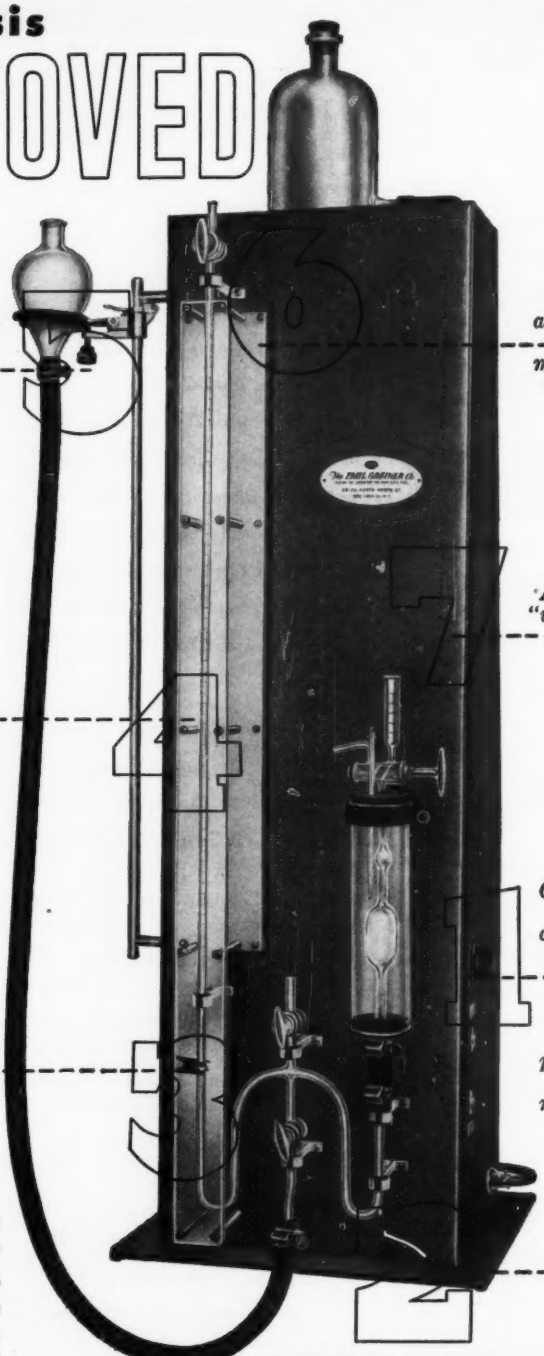
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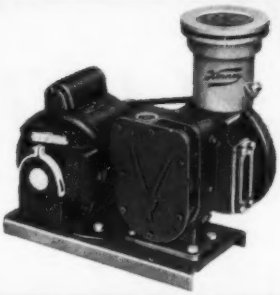

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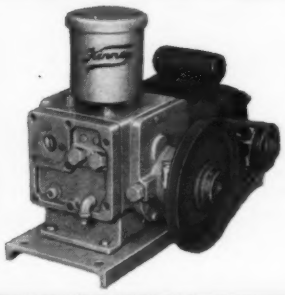

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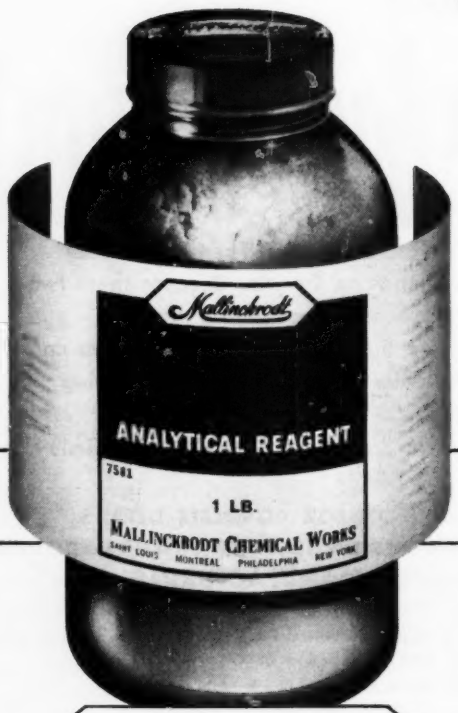

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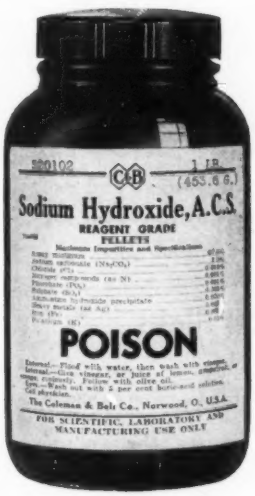

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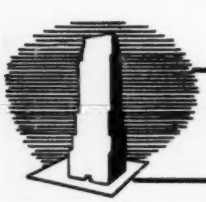

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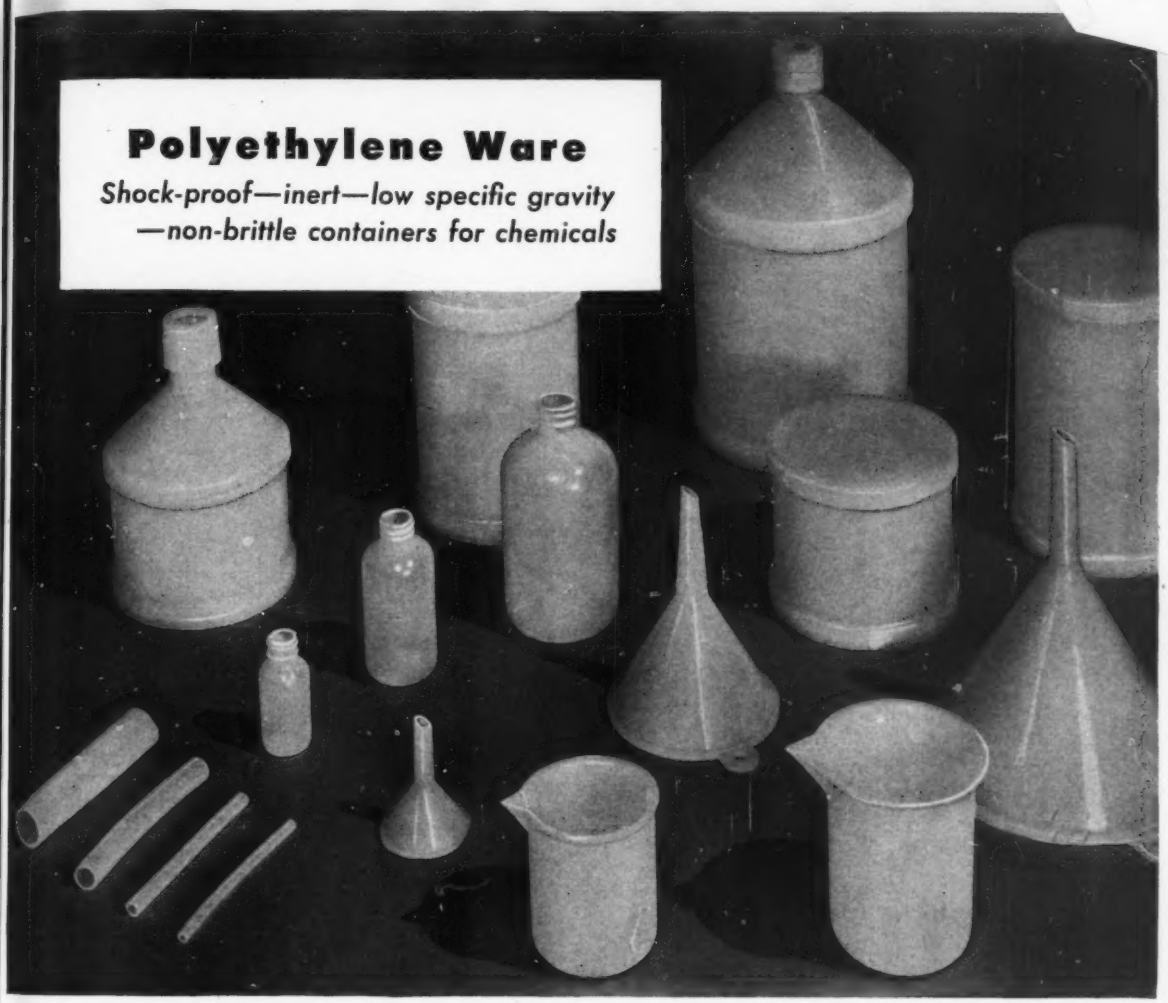

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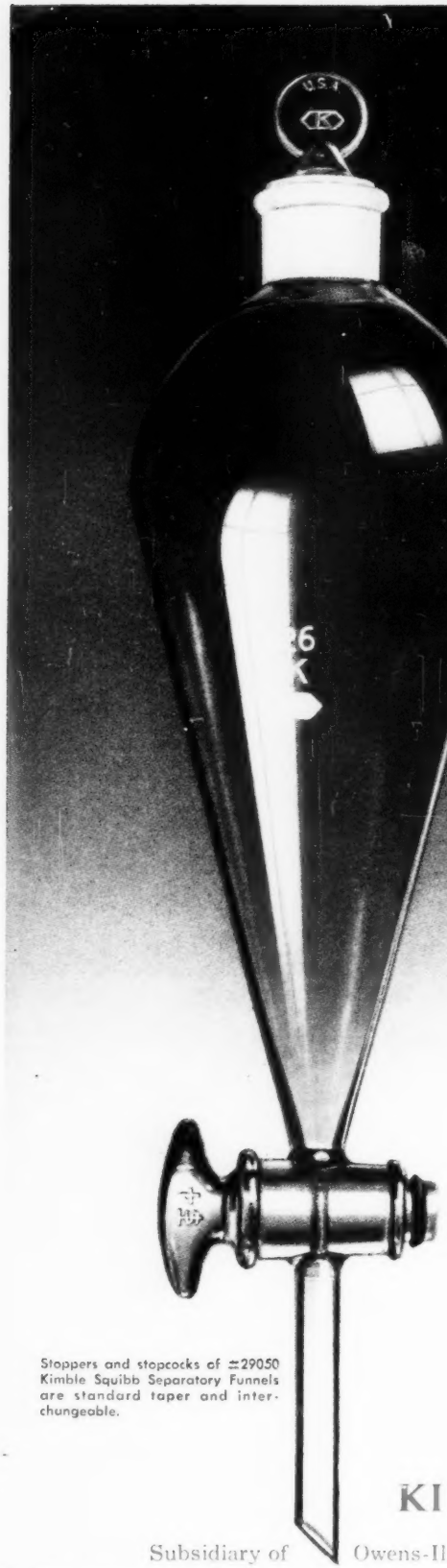

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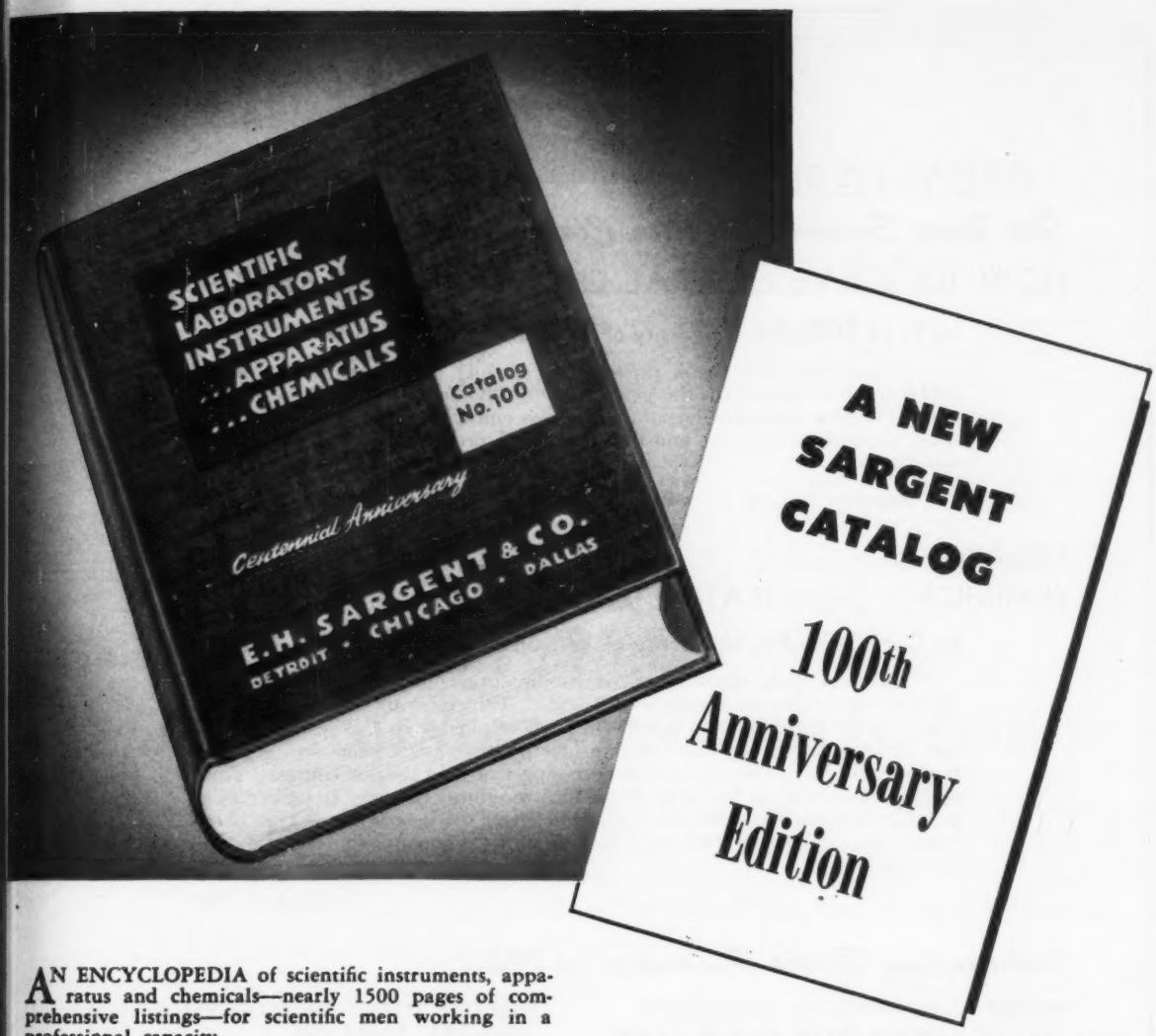

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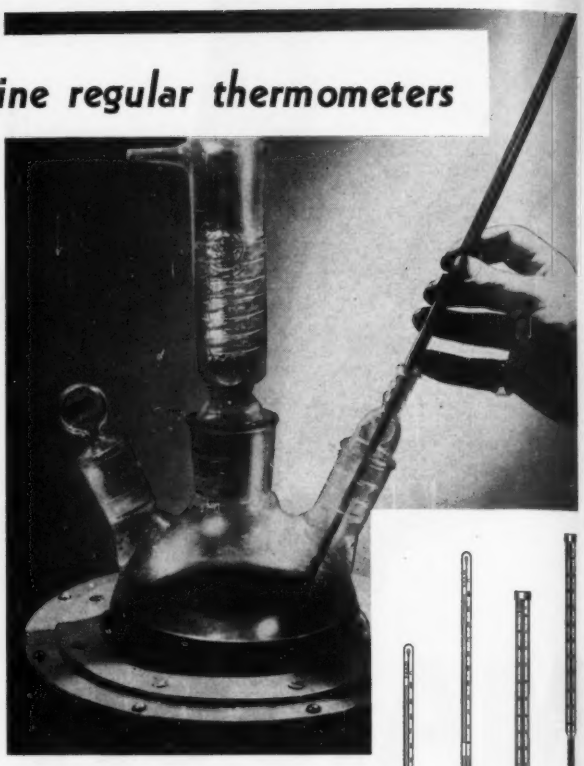

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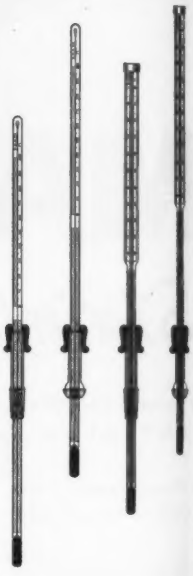

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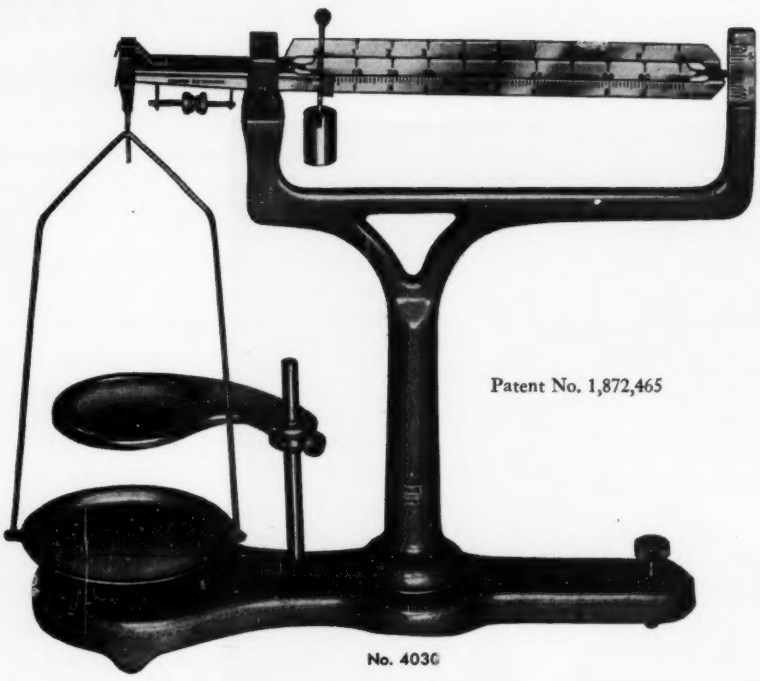

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Editor's Outlook

EVERYONE is concerned these days with the problem of "scientific manpower." It seems to be agreed that the attack on this problem should be from all sides: a frontal attack aimed at overcoming resistance by the weight of heavy numbers, interesting and recruiting many more potential students in the field of science; at the same time flanking movements and guerrilla tactics to pick up a little strength here and stop a little wastage there.

Two contributions to this effort came to our attention recently. The first of these is a suggestion made by L. A. Wetlaufer of the duPont Company at a recent meeting of the Scientific Apparatus Makers Association. To quote *Chemical and Engineering News*, in which the meeting was reported, "He also encouraged college and secondary school authorities to make a more thorough study of the high attrition rate in technical courses." This isn't a new idea, but maybe we haven't thought about it often or hard enough. Without figures at hand upon which to base the belief, I nevertheless feel sure that a larger percentage of students *leave* the major subject of chemistry than any other subject in the college curriculum. This move to other fields of interest may be the result of the lack of ability, or—probably too often—frustration and loss of interest. In the first case there is probably little to be done, without running the risk of lowering the standard of the profession—which is scarcely the way to solve the manpower problem. But the second case should be to a large extent avoidable. Every teacher whose students begin to drop away from him should search his soul and conscience to find out whether the fault is his. Inevitably, students make wrong choices and, for perfectly good reasons, find their interests changing. But when this becomes chronic there is probably something wrong in the teaching. It would be interesting to know whether such "defections" are more common in the larger schools than in the smaller. If so (which I rather suspect), it is evidence for those who maintain that teaching is better and more effective in the smaller institutions than the larger. "A chemist saved is a chemist gained," if one may reckon chemists by the pennysworth, and conversely, every teacher who through fault of his loses a potential chemist makes the job just that much harder for the teacher whose skill is able to attract new ones.

I'm afraid we too often feel that we are well rid of the student whose determination or ability is so weak that he can be shaken out by a little rough treatment. To be sure, we want chemists of great determination and high intelligence, but all students can't be at the top of the class at the same time. Furthermore, there is an uncomfortably large proportion of people who have risen to distinction after an unimpressive start.

The second contribution is the announcement by Mount Holyoke College of the establishment of "an agency of the college to be known as Industrial Associates for Women in Science: a collaboration of science, industry, and the liberal arts." The impulse which led up to it was "a widening recognition today, not only of the need for women trained in science to help meet growing shortages of personnel, but of the need for scientists who have a basic education in the humanities." This event deserves applause, as well as a close watch to see what it may lead to. It has three aspects of interest: it can be a contribution to manpower (through "woman power," which proved enormously useful during the late war); it is a recognition of the peculiar but important relation of the liberal arts college to the training of scientific workers; and it provides a way by which industry can begin to repay the enormous debt it owes to the college. Perhaps the last of these is the most important.

AT LAST we have come to the culmination of a long effort. Elsewhere in this issue will be seen the announcement of our 25-year Cumulative Index. For a long time we have had inquiries about such an index, but its compilation has not been a light job, since it was not done by accumulation of annual indexes but by going back anew to the original numbers. The heavy work was done by Dr. and Mrs. Ross A. Baker, an appropriate arrangement, for Dr. Baker had a good deal to do with the JOURNAL in its early days.

The index has been compiled with the needs of the teacher continually in mind; he will be the principal user. For years, the wealth of teaching material in the earlier numbers of the JOURNAL has been almost inaccessible because of the lack of a suitable subject index. We hope that this has now been supplied. While the science of chemistry has changed a great deal since 1924, there are many aspects of the *teaching* of chemistry which are timeless. In no other place in the world has so much of this material been collected. It is now available for your use.

LEONARDO DA VINCI'S EXPERIMENTS ON COMBUSTION

LADISLAO RETI
"Atanor" Compañia Nacional para la Industria Quimica, S. A. M., Buenos Aires, Argentina

Editor's Note: The publication of this paper at the present time is particularly appropriate, since 1952 is being celebrated throughout the world as the 500th anniversary of Leonardo's birth. His scientific contributions are perhaps less well known in the field of chemistry than in other fields.

Readers will note a peculiar thing about the illustrations—some of them seem to be reversed, for the handwriting goes from right to left. The reason for this is given in "The Literary Works of Leonardo da Vinci," by Jean Paul Richter (Oxford University Press, London, 1939).

"Contrary to the universal custom of western nations, Leonardo committed almost all his notes to paper in a handwriting that goes from right to left. This singular habit has sometimes been accounted for by supposing that Leonardo felt it necessary to put every difficulty in the way of the publication of his works. This assumption, however, seems to me to rest on no solid grounds, and is but an hypothesis at best. Perfectly explicit statements prove, on the contrary that Leonardo wished to publish his writings, and that he cared greatly that they should be known and read; and any one who has taken the trouble to make himself familiar with the Master's writing will, I think, hardly resist the conviction that even the character of the writing was expressly adapted to that view. We know from the evidence of his friend Luca Pacioli that Leonardo drew with his left hand, and used it with perfect ease. In point of fact, in almost every drawing authentically known to be genuine—as those included in the texts of manuscripts must be—wherever shading is introduced the strokes lie from left to right (downwards) as they would be drawn with the left hand.

"The question as to why Leonardo drew and wrote with his left hand has been much discussed and is still of interest. As explained above it seems unlikely that the reason was a wish to keep his writings secret. His earliest notes made when he was twenty-one were also written backwards; and it is improbable that at that early age he should have been in need of such an expedient. It is perhaps more likely that he was deprived of the normal use of his right hand by an accident or in a fight. The Cardinal Luigi d'Aragona has been told by Leonardo himself at Amboise, when paying him a visit in October 1517, that he could only work with his left hand, the right one being crippled."

You investigators therefore should not trust yourselves to the authors who by employing only their imagination have wished to make themselves interpreters between nature and man, but only to the guidance of those who have exercised their intellects not with the hints of nature but the results of their experiments.

And you should grant that experiments deceive those who do not know their nature, because often experiments which look alike are, instead, of great variety, as is here demonstrated.

Leonardo da Vinci[1]

PELADAN claims, in his introduction to a selection of transcriptions of texts by Leonardo da Vinci, that if the master appeared today in a modern academy of science he would have nothing to learn but chemistry; as a physicist and naturalist he would be on a level with those who are four centuries ahead of him. This emphatic overstatement of Peladan is certainly justified by even a superficial examination of the legacy of Leonardo. Approximately 5000 sheets of manuscript have come to us, after countless plunderings and losses. The manuscripts are mostly assembled in codices deposited in the collections of Milan, London, and Paris; of nearly all, facsimiles are available. However, attention is drawn to the exclusion of chemistry from his knowledge and spheres of interest. This opinion appears to be shared by the scholars who transcribed, translated, and commented on the writings of the master, be it in monumental anthologies such as Richter's[2] and MacCurdy's[3] or in numerous monographs.

Leonardo's contributions have been recorded in fields as varied as mathematics, mechanics, optics, acoustics, hydraulics, geology, anatomy, botany, astronomy, physiology, technology, mechanical flying,

[1] "Les Manuscrits de Léonard da Vinci," Les Manuscrits F et I, de la Bibliotheque de l'Institut, par M. Charles Ravaisson-Mollien, Quantin, Paris, 1889.

[2] RICHTER, J. P., "The Literary Works of Leonardo da Vinci," 2nd ed., Oxford University Press, London, 1939.

[3] MACCURDY, EDWARD, "The Notebooks of Leonardo da Vinci," Reynal & Hitchcock, New York.

etc., etc., but references to chemical observations and experiments are scarce. This parsimoniousness about chemistry might be considered natural, given the epoch in which Leonardo lived. Perhaps it was supposed that Leonardo could hardly have applied himself to studying phenomena related to chemistry when this science did not even have a name, and the aversion of Leonardo against the alchemists of his time, "lying interpreters of nature," is well known.

However, a patient study of Leonardo's manuscripts, as has been attempted by the author of the present paper, perhaps for the first time with the eyes of a chemist, reveals a surprising familiarity on Leonardo's part with the chemical arts of his time. Chemistry may not have existed, but chemical phenomena are always observable in nature and in life, and empirical chemical operations already existed since these were required by the refined work of Renaissance artists and craftsmen. A sharp observer, as Leonardo was, of the universality of natural phenomena, an artist-craftsman who fused in himself the whole technological skill of his epoch, could not remain indifferent to the chemical phenomena visible in daily life, nor could he have refrained from utilizing and perfecting the contemporary chemical arts.

The study here presented is actually the first part of a more extensive work in which the chemical references found in Leonardo's papers have been assembled and commented upon. It is far from the author's intention to reconstruct supposed writings of Leonardo on chemical subjects. While there is no doubt that the heritage of Leonardo still contains sufficient material for an attentive reconstruction of books written by Leonardo (and which have been lost) or which he wished to write on hydraulics, geology, anatomy, mechanics, etc., etc., it is evident that chemical references do not form, and never did form, a homogeneous and independent body. It is inadvisable, in this case, to consider the work of reconstruction as recommended by the late Arturo Uccelli, and of which he has offered admirable examples.[4]

At this opportunity, the author wishes merely to mention and analyze that part which corresponds to Leonardo in the solution of one of the fundamental problems of chemistry, the problem of combustion.

Leonardo's participation in the studies of the phenomena of combustion has not so far been generally accepted and evaluated by chemical historians. In a book entirely dedicated to this theme, Gregory[5] hardly so much as mentions it. Stillman[6] and White,[7] on the other hand, give due credit to the ideas of the great encyclopedian of the Renaissance and cite several significant passages in the notes of Leonardo.

The passages are found in the "Codice Atlantico," the largest collection of the master's manuscripts now deposited in the Ambrosian Library in Milan,[8] and have been already transcribed and evaluated by J. B. Venturi, as early as 1797, in his famous Essai.[9]

References made to the phenomena of combustion are the following:

Of Flame. Where a flame occurs, a current of air is started which serves to nourish and increase the flame....

The element fire continuously consumes the air as concerns that portion which nourishes it, and a vacuum would be formed, if other air did not come to supply its place. ["Codice Atlantico," p. 237 v.a.]

Of the Movement of Flame. Where flame cannot live, no animal that draws breath can live. Excess of wind puts out the flame, moderate wind nourishes it. [*Ibid.*, p. 270 v.a.]

As White rightly comments, Leonardo appears to have noticed the part played by air in combustion, nearly three hundred years before Lavoisier. But it is not by a "happy knack of arriving, almost by intuition" that Leonardo resolves a problem which was to worry experimenters for years afterward.

The ancients realized that air was necessary for burning. But the notion of combining air is not so obvious compared with the purely mechanical participation of air in combustion. The flame might suffocate in an enclosed space because the burning body finishes its food or because the flame exhales fouling "fuliginous vapors" and stifles by their accumulation.

How did Leonardo come to the correct answer?

Beside those cited, there are numerous other passages in the manuscripts on the necessity of air to sustain a fire. But it is probably less known that Leonardo arranged deliberate experiments on enclosed combustion.

I found the classical figure of the vessel inverted over water, where a burning charcoal has been placed, sketched several times in Leonardo's papers.

This experiment, performed today as after-dinner amusement by any child, is age-old. Two surprising results are constantly observed: The charcoal or candle burns only for a limited time and after things have settled down, the water level rises in the vessel.

The first description of the experiment, together with an attempt to explain it, is to be found already in the "Pneumatica" of Philo of Byzantium (A.D. 250),[10] but Philo misses the correct interpretation because the observed phenomenon is complex: A part of the air is consumed, a new gaseous substance, carbon dioxide, is formed and the heated enclosed gases escape as bubbles through the water seal. After cooling, the atmospheric pressure makes the water level rise, until external and internal pressures are in balance. Philo's explanation is confused:

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[4] LEONARDO DA VINCI, I libri di Meccanica, nella Ricostruzione Ordinata di ARTURO UCCELLI, Hoepli, Milano, 1942.

[5] GREGORY, JOSHUA C., "Combustion from Heracleitos to Lavoisier," Edward Arnold & Co., London, 1934.

[6] STILLMAN, J. M., "The Story of Early Chemistry," Appleton, New York, 1924.

[7] WHITE, J. H., "The History of the Phlogiston Theory," Edward Arnold & Co., London, 1932.

[8] "Il Codice Atlantico" di LEONARDO DA VINCI, nella Biblioteca Ambrosiana di Milano, riprodotto e pubblicato dalla R. Accademia dei Lincei, da Giovanni Piumati, Hoepli, Milano 1894–1904.

[9] VENTURI, J. B., "Essai sur les Ouvrages Physico-Mathématiques de Léonardo da Vinci," Duprat, Paris, An. V., 1797.

[10] CARRA DE VAUX, BERNARD, "Le livre des Appareils Pneumatiques et des Machines Hydrauliques de Philon de Bysance," Klincksieck, Paris, 1902.

You will see the water in the vessel ascend toward the amphora. This could happen only for the reason which we have stated, namely that the air imprisoned in the amphora vanishes, is exhausted and goes away because of the presence of the flame, and that it cannot subsist with it, and when the air has been dissolved by the movement of the fire, the water rises in proportion to the air that has gone away. This is like what we have seen happen in the siphon; the air is diminished, dissolved by the fire, and that is why the water rises and comes to fill the space which becomes empty.

Sir Francis Bacon (1561–1626) described the same experiment, but did not find the right interpretation. In Bacon's time the experiment was apparently fairly well known, for he speaks of it as *common*.[11]

It was also probably common more than a hundred years before, in Leonardo's time. We find the drawing of the vessel inverted over a water vessel on one of the oldest known writings of Leonardo, page 400 v.a. of the "Codice Atlantico" (Figure 1). The drawing is accompanied by a short instruction: "A lighted charcoal placed in the bottom of this jug, will have the power to fill it with water."

On the same page Leonardo has drawn the head of a blowing child, with the remarks: "When this head is filled up to the mouth with water, if the water boils and the steam escapes only from the mouth, it has the power to kindle a fire."

It is another old scientific curiosity, already described

[11] GREGORY, *loc. cit.* p. 98.

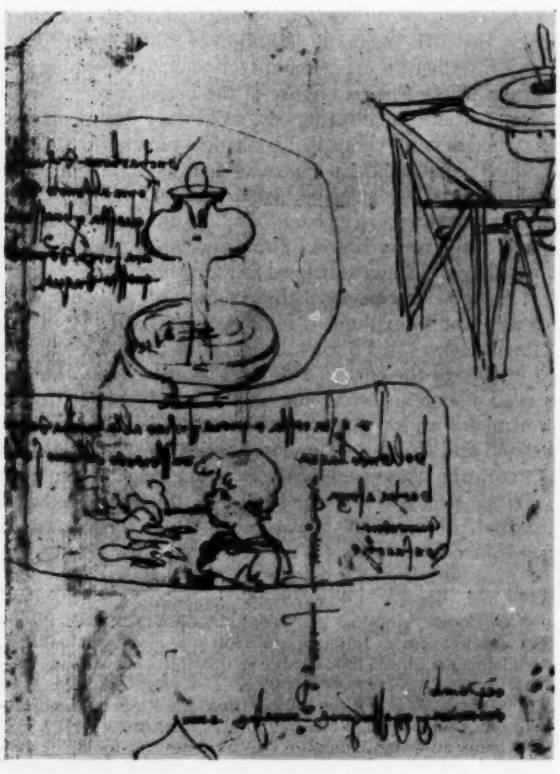

Figure 1

Figure 2

by Albertus Magnus and called "sufflator," of which a detailed account may be found in the works of Feldhaus.[12, 13]

The page has a considerable interest from a paleographic and historic standpoint; it has been reproduced and commented upon by Girolamo Calvi.[14] The page is written with the elaborate calligraphy characteristic of the earliest writings of Leonardo. Calvi observes that the sheet has the same characteristics as a dated page of 1478.

A second, almost identical drawing of the subject appears on page 348 r.a. of the same codex (Figure 2). It is a clean sheet, dedicated entirely to a collection of scientific and mathematical amusements. We are surprised to find here such oldtimers as the cane supported on two glasses, broken by a sudden blow, or the directions for twisting a big nail with the bare hands, or the immortal trick of putting a number of coins in a glass full of water, without spilling a drop. Our experiment on enclosed combustion is another number of the "after dinner science" annotations of young Leonardo. He explains: "Take a jug and set it upside down

[12] FELDHAUS, F. M., "Die Technik der Vorzeit. der Geschichtlichen Zeit und der Naturvölker," W. Engelmann, Leipzig & Berlin, 1914, p. 844.

[13] FELDHAUS, F. M., "Leonardo der Techniker und Erfinder," E. Diederichs, Jena, 1922.

[14] CALVI, GIROLAMO, "I Manoscritti di Leonardo da Vinci," Nicola Zanichelli, Bologna, 1925, pp. 18–19.

in a bowl of water and place a lighted charcoal on the bottom. The heat will have such a power, that the water will rise and fill the said jug."

Calvi places this sheet in the same early group of Leonardo's writing. Both pages may have been written around 1478 and belong consequently to the first Florentine period.

In that period the activities of young Leonardo were solely directed to artistic ends and to practical projects of technology.

Figure 3

The experiments with combustion and with steam are purely amusing curiosities that Leonardo notes down, together with other jokes, to exhibit them, perhaps, in gay and friendly reunions.

It is surprising to find once more the sketch of the vessel inverted over water, together with the head of the blowing boy, in a later sheet, page 80 r.b., of the codex (Figure 3).

It is a page hastily written and drawn: the figures mentioned have no commentaries, but the text undoubtedly permits a relation between this page and the ones numbered 55 v., 56 r., 56 v., and 57 r. of Codex A (2172) from the Institute of France.[15]

The page of the codex must be considered as a first draft on the working of the passages of Codex A, that Leonardo calls: "Beginning of the Treatise on Water."

On page 56 r. of the Institute's Codex A, (Figure 4) we again find the characteristic figure of the experiment. Richter considers this codex to have been written by Leonardo around 1492, that is, during his residence in Milan.

The master becomes increasingly absorbed in scientific studies and he begins to neglect his art. Codex A, with its varied contents, reflects Leonardo's spheres of interest: problems of geometry and perspective alternate with those of mechanics and hydraulics. But above all, his mind is absorbed by the earth's problems. How does water rise to the peak of the mountains, hide in their entrails, to sprout later in fountains, forming rivers?

This is a problem that is to preoccupy him for the rest of his life, and that will lead him to the successive formulation of erroneous theories, until finally he reaches the truth.

In Codex A, Leonardo still tries to demonstrate that by subterranean conduits the water of the sea rises to the mountains, from whence it descends later in the form of brooks and rivers. But how does water rise, challenging the laws of gravity that Leonardo already knows and defines? It is then that the master recalls the amusing experiments noted down in his youth. And following the current opinions on macrocosm and microcosm, he tries to explain:

Explanation of the Presence of Water at the Summits of the Mountains. I say that it is just like the blood which the natural heat keeps in the veins at the top of the man... it is the same with the springs which ramify through the body of the earth and, by the natural heat which is spread through all the body that contains them, the water stays in the springs and is raised to the high summits of the mountains.... Moreover the warmth of the element of fire, and by day the heat of the sun, have power to stir up the dampness of the low places and draw this to a height in the same way as it draws the clouds and calls up their moisture from the expanses of the sea.

As for the proof that heat draws moisture, it is shown as follows: heat a jug and set it in a vase with the mouth downwards, and place there some charcoal which has been lighted. You will see that the moisture, to follow the heat, will rise and fill the jug with water, and the air which was enclosed in this jug will escape through its opening.

Also if you take a wet cloth and hold it to the fire, you will see the damp of the cloth leave its place, and the part of the moisture which has least substance will rise up, drawn by the proximity of the fire which from its nature rises towards the region of its element. In this way the sun draws up the moisture.

We thus see that Leonardo adopts the erroneous interpretation of Plinius and Seneca on the same phenomenon. But Leonardo needs and looks for more causal, more scientific explanations. It must be found out why water rises from the sea until it reaches the sky, in the form of vapor, and from the sea to the heights of

Figure 4

[15] "I Manoscritti e i Disegni di Leonardo da Vinci." Pubblicati della Reale Commissione Vinciana, Vol. II. II Codica A (2172), nell' Istituto di Francia, Libreria dello Stato, Roma, 1936.

the mountains, through the interior of the earth It is the heat that draws moisture. And he presents as proofs experimental models: the experiments with the vessel inverted over water and the phenomena of capillarity which accompanies the drying of a cloth. Under the sketch of a mountain, with its caverns and subterranean channels, there is another poorly defined drawing where Leonardo says: "If you take the instrument *rf* and you heat it on the top, the water will depart from *fr* and, rising, overflow at *a*." Through this image of a kettle heated at the top, Leonardo tries to offer a model of a mountain, heated by the sun; by this action a spring sprouts from the earth. This "instrument" is also found drawn very schematically on page 80 r.b. of the "Codice Atlantico" and replaces the "sufflator" in the final text of the Codex A of the Institute.

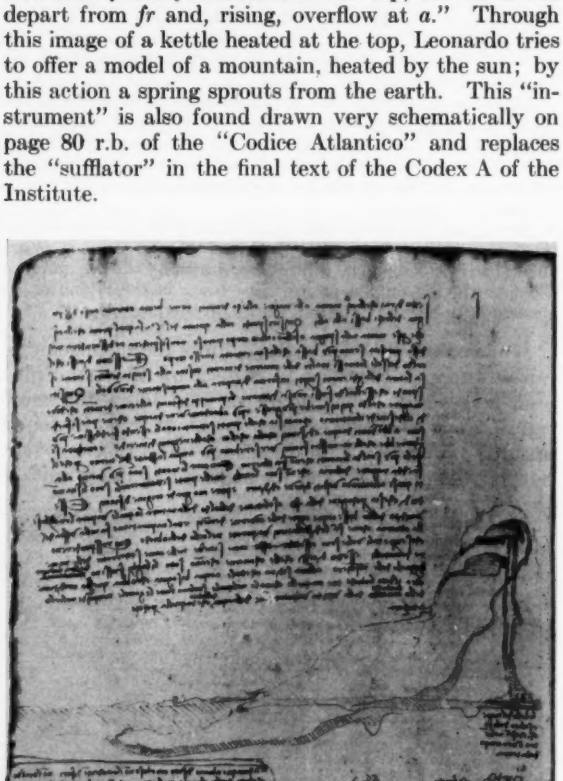

Figure 5

The experiment on enclosed combustion is described once more upon a loose page of the Windsor collection, W., 12641 v.[16]

Clark, in accordance with Marie Herzfeld,[17] dates the page 1504–07, based on analogies with page 15577 of the Royal Library of Torino. Nevertheless, the principal themes of the drawings and of the text relate this page to the others we have just considered ("Codice Altantico" p. 80 r.b. and Codex A, pp. 55–57).

Perhaps the beating human figures, the ones referred to by Marie Herzfeld and Clark, were drawn upon the sheet later on, a fact that can be verified in several of da Vinci's manuscripts.

Many years pass during which Leonardo still meditates on the great problems of the earth. Between 1504 and 1506[18] he edits the manuscript known today as the Leicester Codex.[19] It is one of the most valuable and complete sources for the study of Leonardo's already mature mind. The sheets have been preserved intact and in the order assigned by the master, and the editing is nearly complete, even if it does not represent what we call today "a manuscript ready for printing."

In the sheets of this codex, Leonardo reconsiders his theory on the circulation of water and about the experimental models which he has used in his previous investigations. It is no longer the heat of the sun on the mountains' summits that makes the water of the sea rise, but the earth's volcanic heat [Leicester Codex, p. 28 r.].

> The fire which burns in the body of the earth, heats the water enclosed in great caverns and other cavities; and this heat raises the temperature and evaporates the said waters, and makes them rise to the heights of these cavities and penetrate the mountain's fissures to the highest peaks, where the presence of low temperatures converts them again into water, as is seen to happen in the alembic. The sources of the descending rivers can be traced to the flowing back of the said waters.

In another part of the codex [Leicester Codex, p. 3 v.] we find Leonardo's sincere retraction of his previous convictions, that now, through a polemic fiction, are attributed to the reader:

> If you should say that the water rises to the summit of the mountains drunk or sucked as by a sponge, from the depths to the heights,...the answer is that the water which rises to the top of a sponge or of a felt or other porous body, will not part or descend from the said porosity unless at a point lower to its entrance in the body. And if you should say that the heat of the sun would draw the water from the mountains' caverns to the summits, like vapor is drawn from the open seas and lakes to form the clouds, the answer is that if the heat should be the cause that draws the essence of the rivers to the peaks of the mountains, then where the heat is more powerful the veins of water should be wider and more abundant than in the cold regions: but we see it is the contrary.

In the beautiful and well-detailed sketches (Figure 5) from the same source Leonardo offers the graphic representation of his new theory: at the roots of the mountains there are caverns where, through long and ramified veins, the water that comes from the sea

[16] CLARK, KENNETH, "A Catalogue of the Drawings of Leonardo da Vinci, in the Collection of H. M. the King, at Windsor Castle," University Press, Cambridge, 1935.

[17] HERZFELD, MARIE, "Mitteilungen des kunsthistorischen Institutes in Florenz," 4, Pt. 1, p. 1.

[18] Opinion of G. Calvi (Introduzione, p. XVII) shared by RICHTER, *loc. cit.* p. 400.

[19] "Il Codice di Leonardo da Vinci della Biblioteca di Lord Leicester" in Holkham Hall. Pubblicato sotto gli auspici del R. Istituto Lombardo di Scienze e Lettere, da Girolamo Calvi. Ed. Cogliati, Milano, 1909.

gathers together; underneath those subterraneous lakes is the earth's fire, which provokes the evaporation of the waters. The vapor ascends through other channels up to the heights, where it is condensed by the low temperature and then comes to light, in the form of springs.

Underneath the drawing of a section of the mountain he says: "level of the sea, exhaled by the fire which is found at the center or body of the earth."

This is not the place to examine further Leonardo's ideas and theories about the circulation of the waters on earth. In the Leicester Codex he abandons an erroneous theory for one that is equally erroneous. His powerful imagination has taken him to the conception of titanic alembics which, hidden in the earth's entrails, unceasingly distill the marine waters, giving birth to the rivers.

It is interesting to observe on the same page the perfectly drawn figure of an apparatus of *destillatio per descensum*. The corresponding text reinforces the arguments against those who presume that "heat draws moisture":

> Because the exhalation of the vapors always runs towards their exit, it is required that if the exit of the distillation lies low, such distillation should be descensory. This is against those who affirm that water rises to the mountains because the heat draws the humors to the ceiling of the caverns; it is here demonstrated that they must be directed towards the exit, that is, the beginning of the veins of the rivers.

Farther to the right, on the same page, Leonardo also refutes the experimental foundations of his former theory. Below the drawing of a new experiment of enclosed combustion, he notes:

> If a lighted charcoal is placed on the vessel *n*, the water which was on the level *rs*, will rise to the height *n;* and this does not happen because the heat draws the moisture, but because the air is consumed by the introduction of the fire, which has not enough plenteousness, and the water by itself rises to restore the vacuum. But if you want to be certain that water is not drawn by the fire, make a hole on the vessel *m*, at the point *p*, and you will see that the water will not move from its place.

Leonardo has not yet revealed the mystery of the circulation of the waters on the earth but has resolved, at random, one of the fundamental problems of chemistry! For the first time Philo's experiment has been correctly interpreted.

The experiments described in the pages of the Leicester Codex differ fundamentally from those previously mentioned. In those, Leonardo used vessels of common use, called *guastada* or *amola*. Neither the text nor the drawings allow a conclusive inference on the nature of the experiments, *i. e.*, if the vessels have been heated by external application of burning charcoal or if a true enclosed combustion has been arranged.

In the Leicester Codex Leonardo uses vessels of different shape and larger volume, which he calls *vasi*. That in this case a true experiment on enclosed combustion has been achieved, where the active participation of air is clearly stated, is confirmed by Leonardo's own words: "air is consumed by the introduction of the fire."

It is also significant in the clearness with which he correlates the phenomenon of combustion with the one of animal and even vegetal respiration. He had already affirmed in "Codice Atlantico," page 270 r.a., that: "Where flame cannot live, no animal that draws breath can live." Short but illuminating is the note in Codex Arundel, page 205 v.,:[20] "Because the enclosed fire immediately dies. Similarly in the caves of the granaries."

After Leonardo, the next reference to air as having some part in combustion is to be credited to Robert Fludd. He described in 1617 the experiment on enclosed combustion and drew the conclusion: "water enters the flask in proportion as the air has been consumed. For air nourishes fire and in the nourishing is consumed."[21] It is surprising to discover in this phrase almost exactly Leonardo's wording!

The further development of the ideas on combustion, with Rey (1575–1645), Hooke (1635–1703), Mayow (1643–79), and Boyle (1627–91), and the reign of the theory of phlogiston, are too well known to require discussion here. The experiments with combustion drove Leonardo's indefatigable mind immediately toward practical applications.

Figure 6

On page 7 r.a., "Codice Atlantico," he describes an instrument (Figure 6) in which by the rarefaction of the air, caused by combustion, water is forced to rise from a well. The same principle, in a more elaborate form, is found described on page 5 r.a. (Figure 7). Feldhaus adds: "At the Industrial Exposition of Vienna in 1905, a car was exhibited, on which a big boiler was secured. By lighting a straw-fire in the kettle and connecting it with a well, after cooling down, water was sucked into the boiler by the vacuum formed therein."

Undoubtedly the most interesting practical applica-

[20] "I Manoscritti e i Disegni di Leonardo da Vinci," Pubblicati dalla Reale Commissione Vinciana. Vol. I. Il Codice Arundel 263, Danesi, Roma, 1923–30.

[21] PATTERSON, T. S., "John Mayow in Contemporary Setting," 1932, p. 510. Cited by GREGORY, *loc. cit.*, p. 98.

tion of this phenomenon is to be found in Manuscript F, page 16 (Figure 8). Under the drawing, Leonardo notes:

> To lift a weight with fire, like "cornetto" or "coppetta": and the vessel should be one fathom wide and ten long, and should be strong; the fire should be lighted below, like in a bombard and the hole rapidly closed and immediately closed on top; you will see the bottom rise, which has a very strong leathern valve like the bellows; and this is the way to lift any heavy weight.

This conception of an atmospheric fire engine has been very highly praised by Feldhaus (*loc. cit.*)

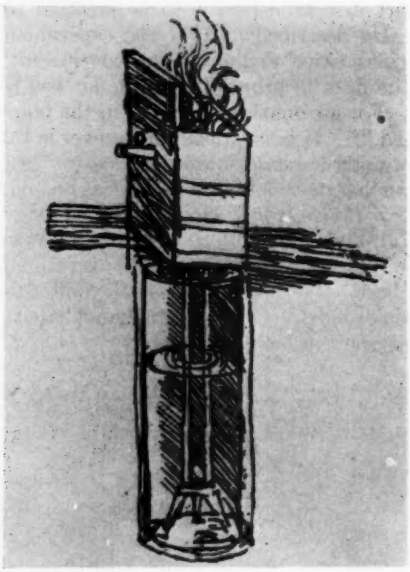

Figure 7

Coming back to our main subject and driving to a conclusion, we may state that the experiments on enclosed combustion, performed by Leonardo, have been executed first as curiosities and later looking for an experimental support for his theories on the circulation of

Figure 8

waters. Later on, he made use of these observations and conclusions in his studies on the nature of the flame.

It is amazing to observe how Leonardo came to the correct interpretation of the phenomenon of combustion 150 years before Fludd and Mayow. It is also remarkable how simple is Leonardo's language, describing chemical operations and phenomena; it is almost modern, compared with the tortuous and deceptive speech of the chemists of the seventeenth and eighteenth centuries.

As for the last word on the circulation of the waters, the old master, driven only by his inextinguishable ardor for truth and knowledge, wrote ["Codice Atlantico," p. 160 v.a.]:

"The water of the rivers comes not from the sea but from the clouds."

MERCK FELLOWSHIP IN ANALYTICAL CHEMISTRY

APPLICATIONS are again being received for the Merck Graduate Fellowship in Analytical Chemistry, financed by Merck & Co., Inc., and administered by the American Chemical Society. The fellowship, which provides for $2500 annually, may be used in attendance at any institution in the United States or Canada approved by the Society or by the Chemical Institute of Canada.

Application blanks may be obtained from the American Chemical Society, 1155 Sixteenth Street, N.W., Washington 6, D. C. They should be completed and returned to the Merck Fellowship Committee, at the same address, along with letters of recommendation and transcripts of credits. Deadline date for receipt of all material is February 1, 1953.

THE VERSENE COMPLEXES[1]

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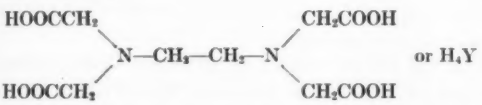
University of California, Los Angeles, California

ETHYLENEDIAMINETETRAACETIC acid was first made available by the I. G. Farbenindustrie (*1*) in 1936 and has since found increasing use as a complexing agent for metallic ions. Its sodium salts are referred to in the literature by several trade names: Versene, Sequestrene, Trilon B, Complexone II, III, or IV, and will hereafter be called "versene." Inasmuch as an excellent bibliography is available (*2*), this paper is not intended as a review, but rather indicates some of the analytical applications with particular reference to polarography. Some of the polarographic characteristics of a number of versene complexes, as determined by the present author, are reported, and its usefulness as a supporting electrolyte is discussed.

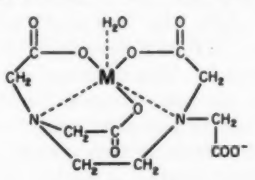
The acid itself



or H_4Y

is sparingly soluble in water and therefore of little interest; however its sodium salts are soluble to the extent of approximately 0.3 *F*. Solutions appear to be stable over long periods of time and are attacked by only the strongest oxidizing agents. The four replaceable hydrogen atoms, with p*K* values of 2.00, 2.67, 6.16, and 10.26 (*3*), allow two practicable titrations to end points at pH 4.5 and 8.2. Figure 1 has been prepared to show the relative amounts of the five possible species present as a function of pH. While this type of graph is not new, it is all too seldom seen and used, and can be a great convenience in interpreting phenomena occurring in solutions of polyprotic acids. It serves to emphasize the necessity for careful control of pH.

The peculiar ability of versene to form very stable complexes results from the availability of four carboxyl and two tertiary amine groups to enter into five-membered rings, each ring including the metal ion.



[1] Presented at the Southwest Regional Meeting, American Chemical Society, San Diego, California, May 10, 1952.

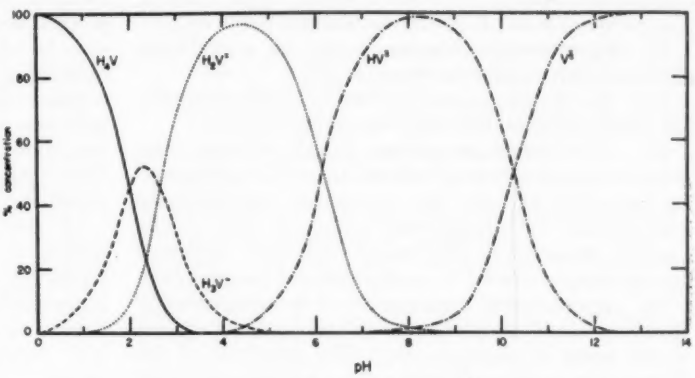


Figure 1. Relative Concentration of Versene Species as a Function of the pH

This system of rings is further stabilized by the ethylenic linkage between the two nitrogen atoms.

The formation of more than four such rings is prevented by steric effects, leaving at least one water molecule in the coordination sphere which is replaceable by such groups as: OH^-, NH_3, SCN^-, etc. (*4*). The central metal ion is thus more or less surrounded by ring structures so that the characteristic reactions of the metal are repressed, and the reduction potentials altered.

The stability constants of a number of these complex ions have been determined by Schwarzenbach and his co-workers (*3*, *5*, *6*), largely from pH measurements of the liberated hydrogen ion. The constants are listed in the table as log *K* for the reaction:

$$M^{++} + Y^{4-} = MY^{--}$$

Stability Constants of Versene Complexes

Metal	*log K*	*Metal*	*log K*
Ni^{++}	18.45	Fe^{++}	14.22
Cu^{++}	18.38	Mn^{++}	13.47
Pb^{++}	18.2	Ca^{++}	3.51
Cd^{++}	16.48	Sr^{++}	2.30
Zn^{++}	16.15	Mg^{++}	2.28
Co^{++}	16.10	Ba^{++}	2.07
La^{+++}	15.40		

A number of techniques are useful in its analytical applications:

(1) Gravimetric separations and determinations in which versene complexes a large number of elements, while others are precipitated by oxine, ammonia, etc. (*7–11*).

(2) Titration of a metal with standard versene solution using a specific indicator (*12*), *e. g.*, water hardness test with indicator eriochrome-schwarz-T.

(3) Addition of excess versene to the metal in solution, followed by determination of the excess versene by titration with standard magnesium solution (*13*).

(4) Addition of excess versene to a neutral solution of the metal, followed by titration of the liberated hydrogen ion to the pH of the reagent (*12–14*).

(5) Titration of an unbuffered, nearly neutral solution of the metal with tetrasodium versene, noting a large increase in pH at the equivalence point (*14*).

(6) Potentiometric determinations at a platinum electrode, particularly for iron (*15, 16*).

(7) Specific applications to redox titration involving otherwise unstable oxidation states (*17–20*).

(8) Colorimetric procedures: (*a*) the versene complexes are more intensely colored than the corresponding aquo ions (*21–24*), and (*b*) versene can eliminate interferences by sequestering unwanted ions in the aqueous phase while the desired element is extracted into an organic solvent as another colored complex (*25*).

(9) Amperometric titrations at the dropping mercury electrode to the disappearance of the diffusion current of the metal in question (*26*). The potential of the electrode is maintained at a value yielding a diffusion current for the uncomplexed metal but not sufficiently negative to cause reduction of the complex formed.

(10) Direct polarographic determinations. Applications are indicated below.

The powerful complexing property of versene suggests its use as a supporting electrolyte for polarographic determinations. Only a few papers concerning the polarography of versene complexes are available,

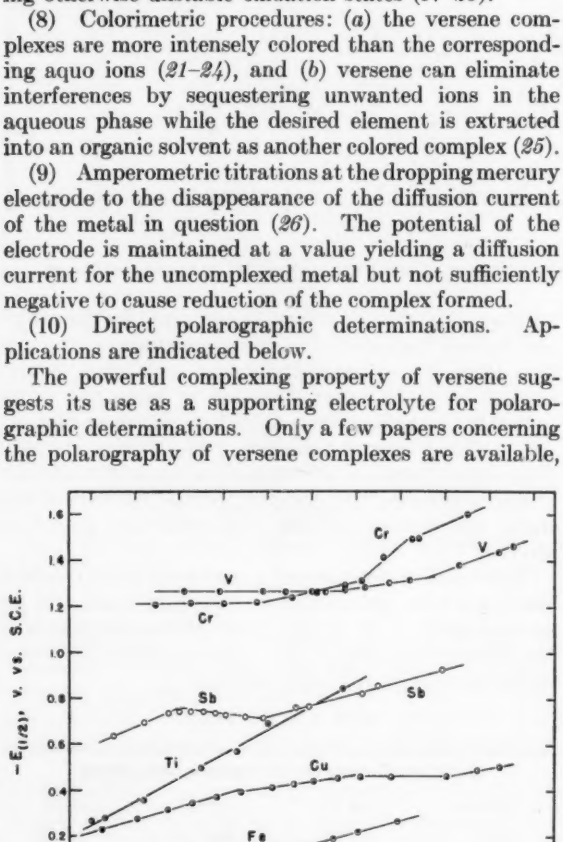


Figure 2. Half-wave Potentials for 0.4 Millimolar Solution of Various Metals in 0.25 *F* Versene as a Function of the pH

and these do not include complete data over wide limits of pH and concentrations. Souchay and Faucherre (*27*) list half-wave potentials for copper, bismuth, titanium, and uranyl ion in 0.1 *M* versene with (*a*) 1 *M* potassium carbonate, pH 9.5, and (*b*) 2 *M* sodium acetate, unstated pH. In a second paper (*28*), the same authors used a mixed versene-citrate buffer, pH 9, to determine iron, copper and bismuth simultaneously in nonferrous alloys. Pfeiffer and Offermann (*29*) apparently did a few polarographic experiments with the copper-versene complex, but did not give any data. Furness, *et al.* (*30*), have used the copper complex in order to analyze commercial versene products. Koryta and Kössler (*31*) described a rather thorough investigation of the cadmium nitrilotriacetic acid (Trilon A) complex, and in the same paper stated that the polarographic waves of the versene complexes were not suitable for determining stability constants. In a very interesting paper concerning the kinetics of versene complex formation, Ackermann and Schwarzenbach (*32*) were able to follow the rate of appearance of the copper-versene complex polarographically. An excellent discussion of the iron-versene system has been reported by Kolthoff and Auerbach (*33*).

In view of the incomplete data available, it was of interest to investigate critically the polarographic behavior of these complexes. The results of a preliminary survey are described below.

Polarograms were recorded with a Sargent Model XXI Polarograph, previously calibrated with a potentiometer. The H-cell with external saturated calomel electrode was maintained in a water thermostat at 25.0°C. All potentials were measured and are reported versus the saturated calomel electrode. The capillary had a rate of flow of 1.811 mg. per sec., and a drop time of 4.65 sec. at −0.5 volt. No maximum suppressors were required.

The pH of solutions was adjusted with sodium hydroxide or nitric acid and measured with a Beckman Model G pH meter.

Reagent grade disodium ethylenediaminetetraacetate was purified by recrystallization. All other chemicals were of reagent grade and were not further purified. Solutions were standardized by accepted procedures.

A number of metals were polarographed in 0.25 *F* versene at small intervals of pH in the range from 3 to 12. The following ions gave no waves before the final current rise, and therefore it must be assumed either that their versene complexes are extremely stable or that their reduction requires considerable overvoltage: stannous, nickel, cobalt, lead, zinc, cadmium, manganous, aluminum, the alkaline earths, and the alkali metals. In analyzing a mixture, the above elements will cause no interference and need not be separated prior to polarographing. Ceric ion yielded a gradually increasing current between zero and one volt, with no well-defined wave at any pH.

The data for a number of metals are presented in Figure 2, in which the half-wave potential for 0.4 millimolar metal in 0.25 *F* versene is plotted versus the pH of the solution. The diffusion current is directly proportional to the concentration for these waves, and therefore they are of potential analytical use. All are well formed and accurately measurable. For the copper wave, this proportionality is within ±2 per cent from 10^{-5} to 0.015 *M* copper.

Provided reversible waves are obtained, the variation

of half-wave potential with pH and concentration of versene can be used to calculate complex formulas and stability constants. Since a number of complexes are possible, *e. g.*, MY^{--}, MHY^{-}, $MYOH^{---}$, and reduction may proceed either to the metal or to a lower oxidation state, no general equation is given. For a reduction of the type:

$$MY^{--} + 2H^{+} + 2e = M + H_2Y^{--}$$

it follows that:

$$(E_{1/2})_c - (E_{1/2})_a = \frac{0.059}{2} \log \frac{K_c}{K_3K_4} - p\,\frac{0.059}{2} \log (H_2Y^{--}) + 0.059\ pH$$

where $(E_{1/2})_c$ and $(E_{1/2})_a$ are the half-wave potentials of the versene complex and the aquo ions, respectively; K_c is the dissociation constant of the complex MY^{--}; K_3 and K_4 are the third and fourth ionization constants of ethylenediaminetetraacetic acid; and p is the number of versene molecules per metal ion in the complex ($p = 1$). Similar equations can be derived for other types of reductions.

No evidence has yet been presented that any complexes exist with a versene to metal ratio greater than 1:1. This is not surprising in view of the extensive ring formations involved.

All of the complexes herein reported, except antimony, yield reversible or nearly reversible waves in the region of pH 3–9, becoming irreversible at higher pH.

The antimony complex yields a well defined, easily measurable wave; however, the experimentally determined equation of the wave indicates a one-electron rather than a three-electron reduction. The half-wave potentials plotted in Figure 2 for the chromium and vandium systems are for the +3 to +2 and +2 to +3 couples, respectively. It should be noted that the large negative potential, about −1.3 volts, represents an extremely powerful reducing agent. Some difficulty was encountered with the chromous complex; measurements must be made immediately after chromous ion is added to the air-free versene solution. Oxidation by water is complete within an hour. The complete investigations of the copper and vanadium systems will be reported elsewhere.

In conclusion, versene appears to be most useful as a supporting electrolyte for the determination of small amounts of iron, copper, bismuth, titanium, antimony, chromium, and vanadium in the presence of large amounts of elements which do not yield waves. If a large excess of either iron or copper is present, preventing accurate measurement of following waves, the reduction of iron can be prevented by the addition of fluoride, and/or copper can be removed by the addition of iodide ion which precipitates cuprous iodide.

Versene complexes offer the polarographer another set of half-wave potentials for metal analysis. In addition, all metals except beryllium can be retained in alkaline solutions. Whether or not versene is superior to other supporting electrolytes will depend on the particular combination of metals involved.

LITERATURE CITED

(1) I. G. Farbenindustrie, German Patent 638,071 (1936).
(2) Alrose Chemical Co., Providence 1, R. I., Technical Bulletins, May and October, 1951.
(3) Schwarzenbach, G., and H. Ackermann, *Helv. Chim. Acta*, **30**, 1798 (1947).
(4) Schwarzenbach, G., *ibid.*, **32**, 839 (1949).
(5) Ackermann, H., and G. Schwarzenbach, *ibid.*, **32**, 1543 (1949).
(6) Schwarzenbach, G., and E. Freitag, *ibid.*, **34**, 1492 (1951).
(7) Pribil, R., *Chimia (Switz.)*, **4**, 160 (1950).
(8) Pribil, R., and J. Kucharsky, *Collection C ech. Chem. Commun.*, **15**, 132 (1950).
(9) Pribil, R., and V. Sedlar, *ibid.*, **16**, 69 (1951).
(10) Pribil, R., and P. Schneider, *Chem. Listy*, **45**, 7 (1951).
(11) Pribil, R., *ibid.*, **45**, 85 (1951).
(12) Schwarzenbach, G., W. Biedermann, and F. Bangerter, *Helv. Chim. Acta*, **29**, 811 (1946).
(13) Biedermann, W., and G. Schwarzenbach, *Chimia (Switz.)*, **2**, 56 (1948).
(14) Schwarzenbach, G., and W. Biedermann, *Helv. Chim. Acta*, **31**, 459 (1948).
(15) Pribil, R., Z. Koudela, and B. Matyska, *Collection Czech. Chem. Commun.*, **16**, 80 (1951).
(16) Schwarzenbach, G., and J. Heller, *Helv. Chim. Acta*, **34**, 576 (1951).
(17) Pribil, R., and V. Malicky, *Collection Czech. Chem. Commun.*, **14**, 413 (1949).
(18) Pribil, R., and V. Simon, *ibid.*, **14**, 454 (1949).
(19) Pribil, R., and J. Horacek, *ibid.*, **14**, 626 (1949).
(20) Pribil, R., and L. Svestka, *ibid.*, **15**, 31 (1950).
(21) Pribil, R., and J. Klubalova, *ibid.*, **15**, 42 (1950).
(22) Pribil, R., and E. Hornychova, *Chem. Listy*, **44**, 101 (1940).
(23) Plumb, R. C., A. E. Martell, and F. C. Bersworth, *J. Phys. and Colloid Chem.*, **54**, 1208 (1950).
(24) Moeller, T., and J. C. Brantley, *J. Am. Chem. Soc.*, **72**, 5447 (1950).
(25) Sedivec, V., and V. Vasak, *Collection Czech. Chem. Commun.*, **15**, 260 (1950).
(26) Pribil, R., and B. Matyska, *Chem. Listy*, **44**, 305 (1950).
(27) Souchay, P., and J. Faucherre, *Anal. Chim. Acta*, **3**, 252 (1949).
(28) Faucherre, J., and P. Souchay, *Bull. soc. chim. (France)*, 722 (1949).
(29) Pfeiffer, P., and W. Offermann, *Ber.*, **75B**, 1 (1942).
(30) Furness, W., P. Crawshaw, and W. C. Davies, *Analyst*, **74**, 629 (1949).
(31) Koryta, J., and I. Kössler, *Collection Czech. Chem. Commun.*, **15**, 241 (1950).
(32) Ackermann, H., and G. Schwarzenbach, *Helv. Chim. Acta*, **35**, 485 (1952).
(33) Kolthoff, I. M., and C. Auerbach, *J. Am. Chem. Soc.*, **74**, 1452 (1952).

REDOX DIAGRAMS

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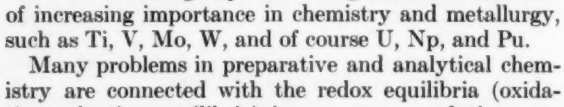
A LARGE number of the elements in the periodic system can exist in more than one oxidation state besides, of course, the pure element (oxidation number zero). Examples from freshman chemistry are Fe, Mn, Cr, and Cl. To this group also belong a number of metals of increasing importance in chemistry and metallurgy, such as Ti, V, Mo, W, and of course U, Np, and Pu.

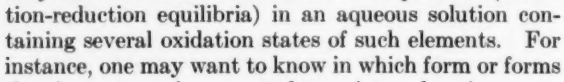
Many problems in preparative and analytical chemistry are connected with the redox equilibria (oxidation-reduction equilibria) in an aqueous solution containing several oxidation states of such elements. For instance, one may want to know in which form or forms the element can be expected to exist under given conditions. The problem may also be the reverse: how to choose the conditions in order to make this or that form of the element predominate over the others.

All the information needed for answering such questions, for mastering the redox equilibria, should be contained in the standard potentials of the redox couples involved; excellent tables of standard potentials have been compiled by Latimer (*1*) and by Latimer and Hildebrand (*2*). However, if one looks up a table of standard redox potentials for an element with several oxidation states such as Mn one finds something as follows (*1*, p. 225):

ACID SOLUTION



BASIC SOLUTION



and one must admit that it is hard to get immediately a clear picture of how the various equilibria interact.

DIAGRAMS FOR SINGLE-VARIABLE EQUILIBRIA

Graphical diagrams have been devised for giving a survey of other types of complicated equilibria. For instance, the very handy logarithmic plots for *acid-base* equilibria (*3*) are based on the fact that for each acid-base pair the ratio [base] : [acid] is a function of one *single variable*, namely the pH of the solution (neglecting the activity corrections). If we plot the *logarithm* of the concentrations of the different acid and base species as functions of pH we get a diagram largely consisting of straight lines of slope zero or ± 1.

A closely related type of equilibrium is the formation of *complexes* between a central atom M and a ligand X. In all such systems that have been thoroughly investigated, not only one "saturated" complex MX_n but the whole series of intermediate complexes MX, MX_2, MX_3, etc., have been shown to exist. In this case, too, there is only *one variable* deciding the ratios between the various complexes, namely the concentration of ligand, [X]. (As before, we assume that the activity corrections either are constant or can be neglected).

Equilibria of complex formation can very conveniently be visualized by diagrams with log [X] on the horizontal axis, as was shown by Niels Bjerrum (*4*). The author (*5*) has used these as well as a few other types of logarithmic diagrams for representing the complicated equilibria between mercury and halogenide ions.

For *solubility* equilibria, logarithmic diagrams have been given by Hägg (*3*).

In the fall of 1949 the author developed for private use diagrams suitable for representing simple or complicated *redox* equilibria (*6*). Since they may be of interest to others, an attempt is made here to describe their principles.

An article in THIS JOURNAL by Delahay, Pourbaix, and van Rysselberghe (*7*) drew attention to diagrams of another type, which we shall call E:pH projections, and which are also intended to illustrate redox equilibria. As will be shown below, the two types of diagram are in many ways complementary to each other. The E:pH projections seem to have been originated by Clark and Michaelis, and developed especially by Pourbaix (*8*) and Charlot (*9*) (see *7*).

The standard potentials used in this paper should be valid for about 25° C. They have been taken from Latimer (*1*) whenever possible, and usually have been rounded off to the nearest 0.01 or 0.005 v. Some of them may be subject to revision. However, a critical review of the literature for standard potentials was considered to be outside the scope of this paper.[1]

REDOX POTENTIALS

In redox equilibria there is one main variable determining the ratios between all the reacting species, namely the redox potential, sometimes called the oxidation potential, of the system. We shall denote the redox potential by E and define E as the e.m.f. of the cell:

$$-\text{Pt, } H_2 \text{ (1 atm.)} \,|\, H^+ \text{ (unit activity)} \,||\, \text{redox system} \,|\, \text{Pt} + \quad (1)$$

[1] Note in proof: The second edition of Latimer (*1*) appeared in the spring of 1952, after the manuscript of this paper had been accepted for publication. Some of the standard potential values in the second edition differ from those in the first; however, it was not thought worth while to redraw the figures accordingly.

The redox system may be only a solution, containing all the reacting species. There may also be a gas phase, or one or more solids (metals, as Ag or Cu, or salts as AgCl). Even if the redox system contains a metal the measured e.m.f. is always a potential difference between two pieces of the same metal; thus the Pt to the right should not be omitted (*10*).

The redox potential E will be *positive* for strongly *oxidizing* systems such as Cl^-/Cl_2 or Ce^{4+}/Ce^{3+}, and *negative* for strongly *reducing* systems as Zn^{2+}/Zn or Cr^{2+}, Cr^{3+}.

Some authors, such as Latimer, (*1*) prefer to use instead the quantity with reversed sign which might be called the "solution potential," to distinguish it from the "metal potential" E. We trust that those readers who may be more familiar with the "solution potentials" will find little difficulty in reversing the signs.

We shall now start with a few simple special redox diagrams and then give the equations for the general case.

IRON(II) AND IRON(III)

In a solution containing both Fe^{2+} and Fe^{3+}, their concentrations are connected to the redox potential by the equation

$$E = E_{32} + \frac{RT \ln 10}{F} \log \frac{[Fe^{3+}]}{[Fe^{2+}]} = E_{32} + 0.06 \log \frac{a_3}{a_2} \quad (2)$$

In this equation, E_{32} is the standard potential E° of the couple Fe^{2+}, Fe^{3+}/Pt. The activities of the iron (III) and iron (II) ions are denoted by a_3 and a_2. In the absence of any complex-forming agents we can, with an approximation sufficient for our present purpose, set a_2 and a_3 equal to the concentrations of the two kinds of ions. The quantity $RTF^{-1} \ln 10$ is 58.17 mv. at 20° C. and 59.16 mv. at 25° C. We can set it equal to 0.06 v. with sufficient accuracy for our present purpose.

Let us rearrange equation (2) to

$$\log a_3 - \log a_2 = \frac{1}{0.06}(E - E_{32}) \quad (3)$$

Equation (3) is given in the standard form we are going to use in the following for redox equilibrium equations. Figures 1*a–c* show three *redox diagrams*, all founded on equation (3) with $E_{32} = 0.77$ v. As in all other redox diagrams in the following, the horizontal axis gives the redox potential E, whereas the logarithms of the concentrations (activities) are on the vertical axis, on a relative scale. The scale of the diagram has been so chosen that one unit on the vertical logarithm scale has the same length as 0.06 v. on the horizontal E scale, and thus 10 logarithmic units (a factor of 10^{10}) corresponds to 0.60 v. In this way as we shall see in the following, the slopes of all lines in the redox diagrams will be integers: 0, ±1, ±2 etc.

For each E value the distance $\log a_3 - \log a_2$ and hence the ratio a_3/a_2 is determined unambiguously by (3). The diagram in Figure 1*a* gives $\log (a/a_2)$ for Fe^{2+} and Fe^{3+}; for Fe^{2+} ($a = a_2$), of course, a horizontal line is obtained at 0, whereas Fe^{3+} ($a = a_3$) gives a line of slope +1. In Figure 1*b*, giving $\log (a/a_3)$ as a function of E, the slopes for a_2 and a_3 are −1 and 0, also in accordance with (3). Finally, Figure 1*c* gives $\log (a_t/a_2 + a_3)$, which is (neglecting the activity corrections) the fraction of all iron ions present that have the oxidation number i.

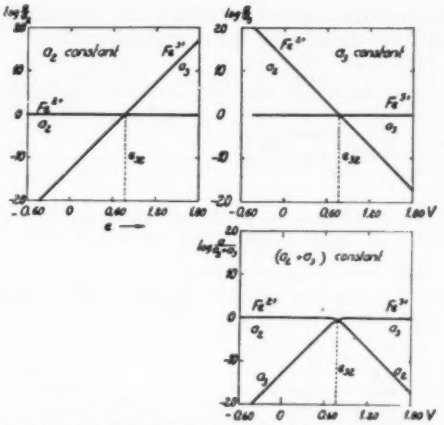


Figure 1. Redox Diagram for Fe^{2+} and Fe^{3+}, $E_{32} = +0.77$ v. The concentrations (activities) of $Fe^{2+}(a_2)$ and $Fe^{3+}(a_3)$ are plotted in three different ways: (*a*) relative to Fe^{2+}: a_2 slope 0, a_3 slope +1, (*b*) relative to Fe^{3+}: a_3 slope 0, a_2 slope −1, (*c*) relative to total iron concentration: $(a_2 + a_3)$ = constant.

These three diagrams, Figure 1*a–c*, are essentially the same; one might imagine the redox diagram as consisting of an infinite number of thin vertical needles in the plane of the diagram, each needle with one mark for a_2 and one mark for a_3. The distance between the two marks is given by (3) for each E value, but the needle can be moved at will in the vertical direction. With a little imagination it is seen how the diagrams 1*a–c* can be transformed into each other by shifting the needles vertically.

All these diagrams show very clearly how Fe^{3+} predominates ($a_3 >> a_2$) in oxidizing solutions, to the right in the diagrams, whereas in reducing solutions (to the left) Fe^{2+} is the dominating form. The two curves intersect at E_{32}, where $a_3 = a_2$. In a narrow range around E_{32}, both ions are present in comparable amounts.

The diagram in Figure 1*c* is analogous to the logarithmic pH diagrams (*3*). Although such diagrams may be somewhat more pedagogical, we shall in the following chiefly use diagrams like 1*a* or *b*, since they contain only straight lines and are thus easier to draw.

IRON(0), IRON(II), AND IRON(III)

Let us assume that a solution containing iron (II) and iron (III) ions is in equilibrium with iron metal (oxidation number 0). We shall denote the activity [Fe] by a_0. For pure iron, $a_0 = 1$; in an alloy a_0 may have values different from 1.

If a foil of platinum or another indifferent electrode is introduced into the solution, its electrode potential

(the redox potential of the solution) must be the same as the electrode potential of the iron. Otherwise we would get a current and a chemical reaction when short-circuiting Fe and Pt, which means that the system would not have been in equilibrium.

This condition gives, denoting the standard potentials of $Fe^{2+}|Fe$ and $Fe^{3+}|Fe$ by E_{20} and E_{30}:

$$E = E_{20} + \frac{0.06}{2} \log \frac{[Fe^{2+}]}{[Fe]} = E_{20} + \frac{0.06}{2} \log \frac{a_2}{a_0}$$

$$E = E_{30} + \frac{0.06}{3} \log \frac{a_3}{a_0}$$

thus

$$\log a_2 - \log a_0 = \frac{2}{0.06}(E - E_{20}) \qquad (4)$$

$$\log a_3 - \log a_0 = \frac{3}{0.06}(E - E_{30}) \qquad (5)$$

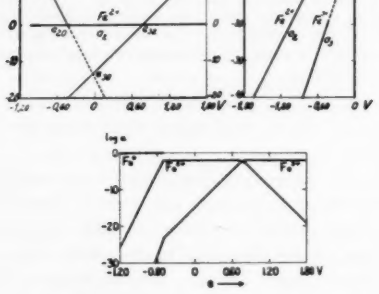


Figure 2. Redox Diagram for Fe. $E_{32} = +0.77$ v., $E_{20} = -0.44$ v., hence $E_{30} = -0.04$ v. The a_0 line is broken where the metal cannot exist at equilibrium. (a) a_2 slope 0, a_0 slope −2, a_3 slope +1, (b) a_0 slope 0, a_2 slope +2, a_3 slope +3, (c) $(a_2 + a_3) = 0.01\ M$, unless $a_0 = 1$.

Figure 2*a* is identical with Figure 1*a* except that the line for a_0 (of slope −2) has been included. At $E = E_{20} = -0.44$, iron metal ($a_0 = 1$) is in equilibrium with a solution where $a_2 = 1$, thus the concentration $[Fe^{2+}]$ is of the order of 1 M. For higher E values the a_0 line has been broken to indicate that Fe metal cannot exist at equilibrium. Already for $E = -0.41$, $a_0 = 1$ would correspond to $a_2 = 10$, an activity that to my knowledge cannot be realized because of the limited solubility of Fe^{2+} salts. Figure 2*b* gives $\log (a_i/a_0)$, and thus the concentration of the ions in equilibrium with pure Fe. The broken lines correspond to equilibria that cannot be realized.

Figure 2*c*, finally, is somewhat similar to Figure 1*c* and shows the activities (concentrations) of the ions in solutions where the total iron concentration is 0.01 M, except in highly reduced solutions were metallic iron precipitates. The two latter diagrams can easily be derived from Figure 2*a* by "sliding the needles." The concentration of Fe^{2+} obviously decreases very rapidly for E values below E_{20}. The concentration of Fe^{3+} is always negligible at equilibrium with metallic Fe.

GENERAL FORMULAS FOR ATOMIC IONS

Let us now consider an element Me that can exist as atomic ions in several different oxidation states: i, k, l ... ; some of these oxidation numbers may be negative or zero. We shall as before denote by a_i the activity (concentration) of the species with oxidation number i, and by E_{ik} the standard potential for the redox couple of the oxidation numbers i and k, thus the redox potential of a system with $a_i = a_k$. For the reaction

$$Me^{i+} + (i - k)e^- \rightleftarrows Me^{k+} \qquad (6)$$

we thus have

$$E = E_{ik} + \frac{0.06}{i - k} \log \frac{a_i}{a_k} \qquad (7)$$

We rearrange equation (7) to give the following connection between a_i, a_k, and the redox potential E of the solution

$$\log a_i - \log a_k = \frac{i - k}{0.06}(E - E_{ik}) \qquad (8)$$

A relation of this type holds for each separate pair of oxidation numbers.

On the "needle" for any E value there will be a mark for each separate oxidation number. We shall construct a redox diagram in such a way that for one of the oxidation numbers the corresponding marks form a horizontal line; it is immaterial which we choose, but in general it is advantageous to choose one of the middle oxidation numbers, since this will make the diagram less space-consuming. It can easily be shown by means of equation (8) that the line for each separate oxidation step will then be straight and that:

(a) The *difference between the slopes* of the log a_i and log a_k lines will be $(i-k)$, the *difference between the oxidation numbers*, and

(b) The lines for any two oxidation states i and k will *intersect at* $E = E_{ik}$, *the standard potential* of the corresponding redox couple.

By means of these two simple rules it is very easy to construct and to check such diagrams.

For an element with n different oxidation states, $\frac{1}{2}n(n-1)$ different standard potentials E_{ik} can be defined. The standard potentials are, however, connected by a number of linear relations. By writing down the equations corresponding to (8) for three different combinations (i, k), (i, l), and (k, l) we can derive the general equation

$$(i - l)E_{il} = (i - k)E_{ik} + (k - l)E_{kl} \qquad (9)$$

In the special case of iron with the oxidation states +3, +2, and 0, we have for instance

$$3E_{30} = 1E_{32} + 2E_{20};\ E_{30} = \tfrac{1}{3}(E_{32} + 2E_{20}) = \tfrac{1}{3}(0.77 - 2 \times 0.44) = -0.04 \text{ v.}$$

This is seen directly from Figure 2a, if we remember that the slope of the log a_0 line is −2 and that of the log a_3 line +1.

THALLIUM, TIN, AND COPPER

In Figures 3, 4, and 5*a* we see redox diagrams for Tl, Sn, and Cu, in all cases drawn with a horizontal line for the intermediate oxidation state. The redox equilibria of copper are also given in a slightly different form in Figure 5*b*, which shows the equilibrium concentrations of Cu^{2+} and Cu^{+} in solutions with the total copper concentration 0.1 M (except in highly reducing solutions where metallic copper precipitates). The information given in Figure 5*b* might also have been obtained from Figure 5*a*.

The diagrams show that for each oxidation state of Tl or Sn there is a not too narrow range of E in which it predominates over the other oxidation states.[2] This is in analogy to the Fe diagram (Figure 2*a*). For Cu, on the other hand, the concentration of Cu^{+} is always low: for $E = E_{20} + {}^1/_2 \cdot 0.06 \cdot \log 0.1 = 0.315$ v. we have the maximum value $a_1 = 10^{-3.4}$ M. For lower E values, $[Cu^{2+}]$ decreases more rapidly than $[Cu^{+}]$ so that at $E = E_{21} = 0.17$ v., $a_1 = a_2$; but then both are as low as $10^{-5.8}$ M.

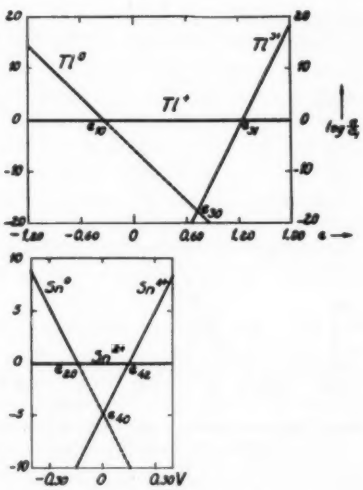


Figure 3 (above). Redox Diagram for Tl $E_{31} = +1.25$ v., $E_{10} = -0.34$ v., hence $E_{30} = +0.72$ v.

Figure 4 (below). Redox Diagram for Sn. $E_{42} = +0.15$ v., $E_{20} = -0.14$ v., hence $E_{40} = +0.005$ v.

EQUILIBRIA WITH H^+ AND COMPLEX-FORMERS

We have hitherto assumed that the element in its various oxidation states occurs only in the form of atomic ions Me^{z+}, perhaps with some water of hydration. However, the element may also be combined with other atoms. Sometimes these other atoms may be only O and H, as in $V(OH)_4^+$, VO^{2+}, UO_2^{2+}, MnO_4^-, MnO_2(s), and FeOOH(s). The formula for the redox reaction will then contain also H^+ and H_2O (or OH^- and H_2O).

[2] The measurements of E_{42} for Sn (*11*) really seem to refer to equilibria with $SnCl_6^{2-}$. It might be more correct to replace "Sn^{4+}" in Figure 4 by $SnCl_6^{2-}$ assuming $[Cl^-] = 1$, and use a slightly lower value for E_{42}. However, we shall stick to the policy of accepting the data in (*1*).

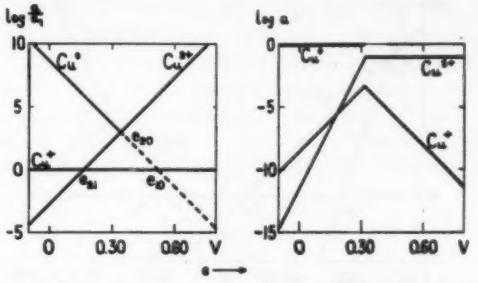


Figure 5. Redox Diagram for Cu. $E_{20} = +0.345$ v., $E_{21} = +0.17$ v., hence $E_{10} = +0.52$ v. (*a*) a_1 slope 0, (*b*) $a_1 + a_2 = 0.1$ M, unless $a_0 = 1$.

Let us for instance consider vanadium with the oxidation numbers +5 and +4. In an acid solution the predominant kinds of molecules seem to be $V(OH)_4^+$ (sometimes written VO_2^+,) and VO^{2+}. The redox reaction is then

$$V(OH)_4^+ + 2H^+ + e^- \rightleftarrows VO^{2+} + 3H_2O.$$

Writing E_{54} for the standard potential of this reaction, and a_5, a_4, and h for the activities (approximately the concentrations) of $V(OH)_4^+$, VO^{2+}, and H^+, we find

$$E = E_{54} + 0.06 \log \frac{a_5 h^2}{a_4}$$

from which since

$$-\log h = \mathrm{pH}$$

$$\log a_5 - \log a_4 = \frac{1}{0.06}(E - E_{54}) + 2\mathrm{pH} = \frac{1}{0.06}(E - E^*_{54})$$

$$E^*_{54} = E_{54} - 2\mathrm{pH} \cdot 0.06$$

In the same way we find for the reaction

$$UO_2^{2+}(a_6) + 4H^+ + 2e^- \rightleftarrows U^{4+}(a_4) + 2H_2O$$

$$\log a_6 - \log a_4 = \frac{2}{0.06}(E - E^*_{64})$$

$$E^*_{64} = E_{64} - 2\mathrm{pH} \cdot 0.06$$

and for

$$AuCl_4^-(a_3) + 2e^- \rightleftarrows AuCl_2^-(a_1) + 2Cl^-$$

$$\log a_3 - \log a_1 = \frac{2}{0.06}(E - E^*_{31})$$

$$E^*_{31} = E_{31} + \mathrm{pCl} \cdot 0.06$$

where $\mathrm{pCl} = -\log [Cl^-]$.

In general, if we can write the formula for the redox reaction

$$(\text{ox. state } i) + (i - k)e^- + n\mathrm{H}^+ + x\mathrm{X} \rightleftarrows (\text{ox. state } k) \quad (10)$$

we can deduce the relation

$$\log a_i - \log a_k = \frac{i - k}{0.06}(E - E^*_{ik}) \quad (11)$$

where

$$E^*_{ik} = E_{ik} - \frac{0.06}{i - k}(n\mathrm{pH} + x\mathrm{pX}) \quad (12)$$

Of course, one of n and x or both may be negative or zero; as usual $\mathrm{pX} = -\log [X]$.

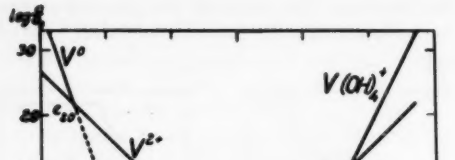


Figure 6. Redox Diagram for V at pH = 0. E_{41} = +1.00 v., E_{12} = +0.31 v., E_{23} = −0.20 v., E_{30} = −1.5 v.

For complicated redox reactions one may draw a series of diagrams. In each diagram the pH value and the concentrations of the possible complex-formers X are kept constant; then within the particular diagram the values of E^*_{ik} remain constant, and the diagram can be constructed in exactly the same way as for atomic ions, since equation (11) has the same form as (8).

The constants E^*_{ik} might be called the *formal potentials* or the *practical* standard potentials under the special conditions of the diagram. This is exactly what is obtained when "standard potentials" are measured in 1 *M* HCl, 1 *M* H_2SO_4, 1 *M* $HClO_4$, etc.

V, Ti, U, Np, AND Pu

Figures 6 and 7 give the redox diagrams for V and Ti, both at pH = 0. Each oxidation state has obviously one *E* range in which it predominates. The equilibria with metallic V or Ti to the extreme left in the figures probably cannot be realized with an aqueous solution of pH = 0 because of the evolution of hydrogen at such low *E*.

In Figure 6 the various formal (since pH = 0, also standard) potentials have been marked out as the points of intersection.

If pH is changed, the positions of the lines for species of formula Me^{2+} will remain constant, whereas ionic species containing excess oxygen will move. For instance, with increasing pH the lines for the VO^{2+}, $V(OH)_4^+$, and TiO^{2+} will be raised relative to the others, as shown by (12) and (11).

Figures 8–10 give redox diagrams for the closely related elements U, Np, and Pu at pH = 0. These three elements (like americium) all have the oxidation states +3, +4, +5, and +6; in the higher two oxidation states the formulas of the free ions seem to be MeO_2^+ and MeO_2^{2+}. All three diagrams have been drawn so as to make the line for Me^{4+} horizontal.

The diagrams bear out the increasing stability of the lower oxidation states of these elements with increasing atomic number. The +3 state for U is difficult to obtain because of the evolution of hydrogen at such low *E* values. For Np and especially for Pu the +3 state predominates in the intermediate range of redox potential. We also see that it takes higher redox potentials to make the neptunyl and plutonyl ions predominate than to obtain the uranyl ion, UO_2^{2+}.

The equilibrium concentration of the ion UO_2^+(oxi-

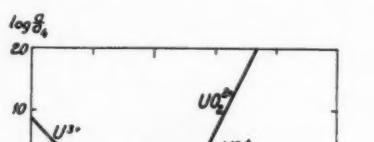


Figure 8. Redox Diagram for U at pH = 0. E_{23} = +0.05 v., E_{34} = +0.40 v., E_{11} = −0.69 v. (*12*).

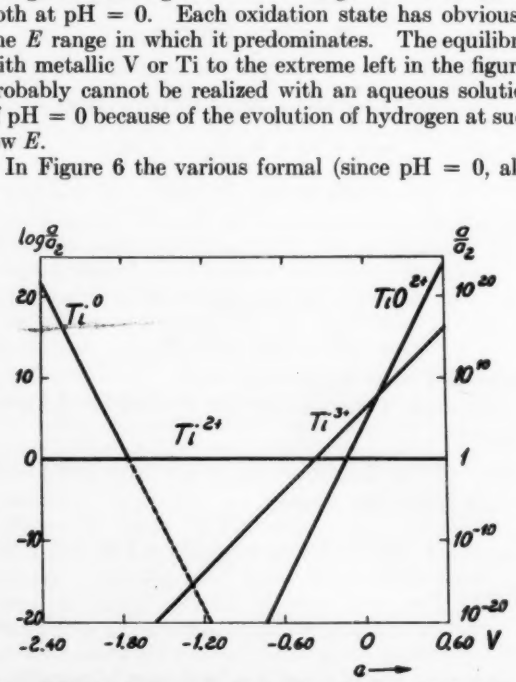


Figure 7. Redox Diagram for Ti at pH = 0. E_{12} = +0.1 v., E_{23} = −0.37 v., E_{30} = −1.75 v.

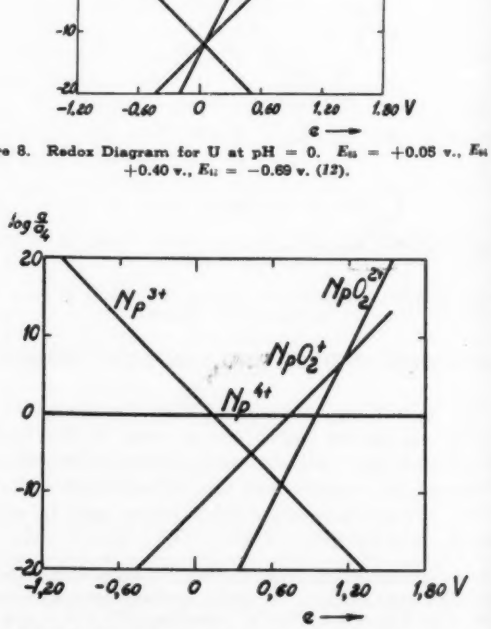


Figure 9. Redox Diagram for Np at pH = 0. E_{12} = +1.14 v., E_{23} = +0.79 v., E_{11} = +0.14 v. (*13*, in 1 *M* HCl).

dation state +5) is always low; the maximum relative amount is obtained at E_{64}, the intersection of the U^{4+} and UO_2^{2+} lines, as may be seen from Figure 8 using some imagination. The yield may be raised by increasing the pH, since then the two curves UO_2^{2+} and UO_2^{+} will rise relative to the others. For Np, on the other hand, the +5 state has (like the other oxidation states) a range of its own, whereas for Pu there is an E range around +1.0 v. where appreciable amounts of all four oxidation states, +3, +4, +5, and +6, are present at equilibrium (Figure 10).

CHLORINE AND IODINE

Figures 11*a* and *b* show redox diagrams for Cl at pH = 0 and pH = 14. In both diagrams, the line for the +3 state ($HClO_2$ or ClO_2^-) has been chosen horizontal, and the vertical scale is half that in the previous diagrams. The line for Cl_2 is valid only for a chlorine pressure $a_0 = p_{Cl_2} = 1$ atm. For other chlorine pressures it will be slightly shifted, as one can see from the equations:

$$^1/_2Cl_2 + \epsilon^- \rightleftarrows Cl^-$$

$$^1/_2 \log a_0 - \log a_{-1} = \frac{1}{0.06}(E - E_{0,-1}) \qquad (13)$$

Because of the "$^1/_2$" appearing for $\log a_0$ but not for the other oxidation states, the equilibrium ratios containing a_0 will not be independent of the chlorine pressure. For instance, for $a_0 = 0.01$ atm., the line for Cl_2 will be 1 unit lower relative to the others, which however does not change the general shape of the diagram. (Instead of setting $a_0 = p_{Cl_2}$ one might change the standard state in the second case and set $a_0 = 1$ for $p_{Cl_2} = 0.01$ atm. Then the Cl_2 line comes out higher by 1 unit than for 1 atm.)

The diagram shows that the only two ionic species that would be stable at real equilibrium are Cl^- and ClO_4^-. Actually, the activities of Cl^- for low E and ClO_4^- for high E would be so much greater than those of the other species that the corresponding lines are high above the area covered by Figures 11*a* and *b*.

If the formation of the ClO_4^- ion is retarded by some reaction step being very slow, the next stablest ion is

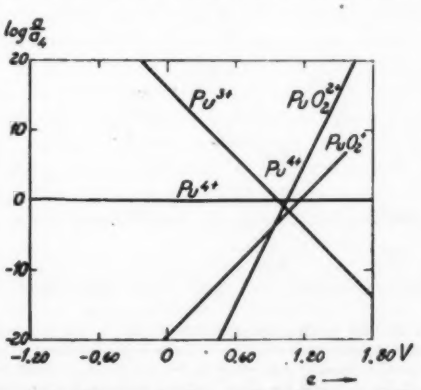


Figure 10. Redox Diagram for Pu at pH = 0, E_{43} = +0.93 v., E_{64} = +1.08 v., E_{51} = +0.97 v. (*14*).

ClO_3^-; all other ions, as well as the acids and the chlorine dioxide, are unstable with regard to the formation of ClO_4^- (ClO_3^-) and Cl^-. In the "acid" diagram there is a stability range for Cl_2 (g). Thus, if Cl^- and ClO_3^- are mixed in an acid solution, gaseous chlorine will evolve until the concentration of at least one of the two ions has been considerably depressed.

Let us consider what happens when elementary chlorine is introduced into an alkaline solution, say with

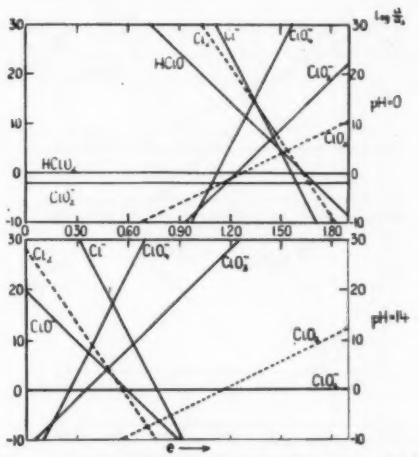


Figure 11. (a) Redox Diagram for Cl at pH = 0; E_{75} = 1.00, E_{50} = 1.23 (with $HClO_2$), E_{43} = 1.28, E_{31} = 1.63, E_{10} = 1.63, $E_{0,-1}$ = 1.36. (b) Redox Diagram for Cl at pH = 14. Standard Potentials (with OH^- in redox reactions): E_{75} = 0.17, E_{43} = 0.35, E_{31} = 1.15, E_{11} = 0.59, E_{10} = 0.52, $E_{0,-1}$ = 1.36.

pH = 14. Assuming that all types of negative ions are formed, one finds for the concentrations

$$[Cl^-] = 7[ClO_4^-] + 5[ClO_3^-] + 3[ClO_2^-] + [ClO^-] \qquad (14)$$

From Figure 1*b* and equation (14) one may see that at real equilibrium Cl^- and ClO_4^- would be the only ions present in appreciable amounts. The line for $\log (7[ClO_4^-])$ would run very slightly above the line for $\log [ClO_4^-]$ given in the figure; $\log 7 = 0.845$ is a small quantity on the vertical scale, and still smaller is the activity correction. Equation (14) corresponds to the point of intersection of the log lines for $7[ClO_4^-]$ and $[Cl^-]$—all other concentrations are seen to be negligible—which is but slightly to the left of the intersection of the lines for $[Cl^-]$ and $[ClO_4^-]$.

Actually the formation of ClO_4^- seems to be very slow; what is formed with hot solutions is the next stablest ion, ClO_3^-. With cold solutions, ClO^- is the chief product; the intersection point $[Cl^-] = [ClO^-]$ is below the lower edge of Figure 11, and it is seen that the formation of all other ions: ClO_2^-, ClO_3^-, and ClO_4^-, must be retarded.

Chlorine is a rather extreme example of *retarded reactions*. The slowness of some reactions may put a limitation on the validity of redox diagrams and, by the way, of all equilibrium calculations.

The diagrams show what the activities of the various

species would be if real equilibrium were attained. From this one may conclude whether a certain reaction is possible or not; *e. g.*, Figures 11*a* and *b* show that under the conditions of the diagrams ClO_4^- and Cl^- will not react to form ClO_3^-. However, the diagrams allow no conclusion concerning the velocity with which a system will approach equilibrium.

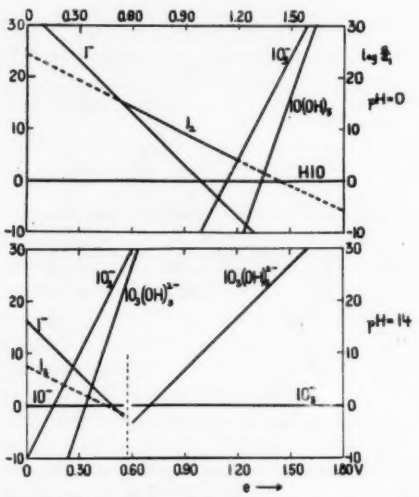


Figure 12. (*a*) Redox Diagram for I at pH = 0. E_{75} = 1.70, E_{51} = 1.14, E_{10} = 1.45, $E_{0,-1}$ = 0.53. (*b*) Redox Diagram for I at pH = 14. Left Part a_1 Slope 0, Right Part a_4 Slope 0. Standard Potentials (with OH^- in redox reactions): E_{75} = 0.7, E_{51} = 0.15, E_{10} = 0.45, $E_{0,-1}$ = 0.53

Figures 12*a* and *b* are the corresponding diagrams for iodine, drawn with a horizontal line for the oxidation number +1 (for +5 in the right part of Figure 12*b*). The diagrams bear out the fact that in acid solution I^- and IO_3^- react to form $I_2(s)$, whereas $I_2(s)$ is not stable at pH = 14. Moreover, Figure 12*b* indicates that at pH = 14 the equilibrium $3\ IO^- \rightleftarrows IO_3^- + 2I^-$ is displaced to the right, which agrees with experience. (The "basic" E_{51} should be 0.15 v. and not 0.56 as misprinted in (*1*).)

MANGANESE

Figure 13 gives redox diagrams for Mn at the pH values −5, 0, 6, 14, and 19. These diagrams can easily be constructed using (11), (12), and the standard potentials given in the introduction of this paper. For the "basic" potentials, it is convenient to regard OH^- as a ligand X. In all diagrams the line for the +4 state, $MnO_2(s)$, has been chosen horizontal. However, in order to save space the equilibrium between Mn^0 and Mn^{2+} has been given separately with Mn^{2+} horizontal, at the extreme left of the diagrams.

The pH values −5 and +19 are not at all impossible to achieve; actually these are the estimated approximate pH values in 66 per cent H_2SO_4 (*15*) and in saturated aqueous NaOH or KOH (*16*).

In the diagrams there should also be a line for the blue MnO_4^{3-} ion (oxidation state +5), which has recently been discovered by Lux (*17*).

The reader may prefer to correlate for himself these diagrams and the known facts from the chemistry of manganese. It should be remembered that these diagrams, like the previous ones, give only ratios of activities. Where a solid substance appears, such as MnO_2, $Mn(OH)_3$ (perhaps rather MnOOH), $Mn(OH)_2$, or Mn^0, the activity is as usual defined so as to be unity for the pure solid compound. If for instance $a_4 = 1$, this means that the solution can exist in equilibrium with solid MnO_2; if $a_4 < 1$, solid MnO_2 cannot precipitate, and finally if $a_4 > 1$, the solution is supersaturated

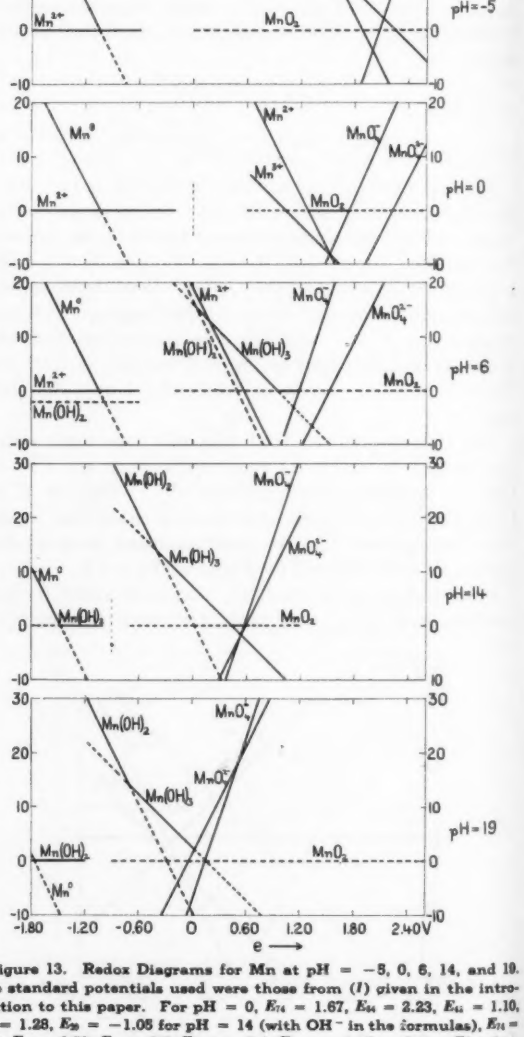


Figure 13. Redox Diagrams for Mn at pH = −5, 0, 6, 14, and 19. The standard potentials used were those from (*1*) given in the introduction to this paper. For pH = 0, E_{74} = 1.67, E_{44} = 2.23, E_{41} = 1.10, E_{42} = 1.28, E_{20} = −1.05 for pH = 14 (with OH^- in the formulas), E_{71} = 0.57, E_{74} = 0.58, E_{42} = 0.5, E_{22} = −0.4, E_{20} = −1.47. Other E^* values calculated using (12).

with respect to MnO_2, and will sooner or later pass to an equilibrium state where $a_4 = 1$. For this reason, the practical maximum value for the activity of a solid is 1; the line for a solid has been drawn as broken in such regions where the solid could not exist at equilibrium.

A THREE-DIMENSIONAL DIAGRAM

The plots in Figure 13 may be regarded as sections of a three-dimensional diagram with pH and E as horizontal axes and log a_i as the vertical one.

We may imagine the three-dimensional diagram also as built up of infinitely thin vertical needles; each needle is characterized by a certain couple of E and pH values and thus by definite ratios between the various a_i. We may imagine marks for the various log a_i at definite distances on the needle.

The needles may be moved vertically at will. In Figure 13 we have agreed to make all the points for $MnO_2(s)$, log a_4, lie on a horizontal plane; correspondingly the points for any other species will fall on a slanting plane, as may be proved using (11) and (12).

Let us imagine that we are viewing this array of planes from above, and that the planes are nontransparent so that we see a certain plane only when it is above all others. What we shall then see is pictured in Figure 14.[3] This picture does not change if the "needles" are shifted vertically.

If in a certain area the species given is a soluble ion this means that at equilibrium this ion will predominate in the solution and no solid compound be present. If a solid is indicated, this solid may exist at equilibrium under the conditions given, and the concentrations of all soluble species will be less than, and generally much less than, 1 molar.

The diagram in Figure 14 is of the same type as those given by Delahay, Pourbaix, and van Rysselberghe in (*7*), only turned 90° around. Thus the two types of diagrams are based upon the same three-dimensional diagram log a_i:E:pH. The redox diagrams give log a_i:E for sections with a constant pH, and the E:pH plots give projections of the top surfaces seen from the positive log a_i axis.

The two types of plots are complementary. The E:pH projections give a good first survey of the equilibria involved. The logarithmic plots, "redox diagrams," give more detail, and are very easy to construct from the standard potentials by means of equations (11) and (12). Actually the simplest and most fool-proof way of obtaining E:pH projections seems to be first constructing redox diagrams for a series of pH values, then drawing the corresponding lines on the E:pH plot, and marking out on each line the E range where each separate species predominates. The reader may check Figure 14 against the plots in Figure 13 by laying a ruler horizontally at the various pH values.

The redox diagram tells something about the concentrations of species other than the dominating one. Some, *e. g.*, Cu^+ and UO_2^+, would not even find a place in the E:pH projection. The redox diagram also gives in a convenient way the connections between various standard potentials (see *e. g.*, Figure 6.).

POLYNUCLEAR MOLECULES

In our present discussion it has usually been tacitly assumed that each element, Me, is present either as mononuclear separate molecules in solution or as a solid substance of constant activity. A small complication occurs when in one of the oxidation states we have a gas or a dissolved substance with polynuclear molecules, such as Hg_2^{2+}, $Cr_2O_7^{2-}$ or $Cl_2(g)$. We have already met this complication for chlorine. The conditions will be analogous in other cases. In the equation corresponding to (11), the log a terms for the polynuclear molecules will have a coefficient less than 1, *e. g.* $^1/_2$ or $^1/_3$. On a vertical needle in our redox diagram the point for a polynuclear molecule will be fixed only if the activity of one of the different oxidation states has been defined. Thus, for drawing a redox diagram we must make some assumption about the activity of at least one of the oxidation states; if this assumption is changed, the position of a "polynuclear" line will move relative to the others. The simplest assumption is setting the activity for the polynuclear molecules equal to unity; then the standard potentials can be immediately applied. Such diagrams will still give a very good survey of the equilibrium conditions, especially since the shifts of the "polynuclear" lines will be rather small if one keeps within the usual concentration range.

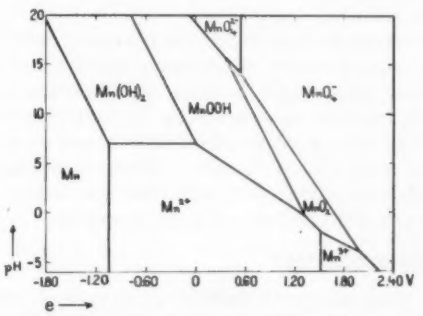


Figure 14. E:pH Projection for Mn, Constructed from the Cuts for Five pH Values in Figure 13

THE pE SCALE

The equations used above would be still more simplified by introducing the quantity pE (*18*)

$$pE = \frac{EF}{RT \ln 10} \simeq \frac{E}{0.06} \qquad (15)$$

If $pH = -\log[H^+]$ is a measure of the proton ac-

[3] Added in proof: One may think that in Figure 14 the field of MnOOH is unexpectedly large in comparison with that of MnO_2. On the other hand, with the very different "basic" E_{32} and E_{43} proposed in Latimer's (*1*) 1952 edition, MnOOH (or $Mn(OH)_3$) would be unstable and tend to change into a mixture of $Mn(OH)_2$ and MnO_2. Then the MnOOH field would disappear completely from the diagram in Figure 14. This may be an exaggeration in the other direction.

tivity, we might say that $pE = -\log[e^-]$ is a measure of the electron activity in the solution, choosing the hydrogen-saturated solution of the standard hydrogen electrode as the standard state for e^-.

pE will obviously be positive in oxidizing solutions, and negative in reducing solutions.

Introducing pE, equations (11) and (12) take the form

$$\log a_i - \log a_k = (i - k)(pE - pE_{ik}^*) \quad (16)$$

$$pE_{ik}^* = pE_{ik} - \frac{npH + xpX}{i - k} \quad (17)$$

Since the use of potentials for expressing the oxidizing power of a solution is so firmly rooted, there seems to be little hope of getting the pE scale universally adopted, at least in the very near future.

We have seen how redox diagrams can be used for getting a quick survey of the redox equilibria of various elements. One might increase the apparent accuracy by using more decimals in the E_{ik}, by replacing 0.06 with RTF^{-1} ln 10, *e. g.*, 0.05916 for 25° C., and even by correcting for the activity factors. However in view of the redox data available, it is felt that this would require more work and yield no real gain in accuracy.

ACKNOWLEDGMENT

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LITERATURE CITED

(1) LATIMER, W. M., "The Oxidation States of the Elements and Their Potentials in Aqueous Solutions" ("Oxidation Potentials"), Prentice-Hall, New York, **1938.**
(2) LATIMER, W. M., AND J. H. HILDEBRAND, "Reference Book of Inorganic Chemistry," Revised ed., Macmillan, New York, **1940.**
(3) HÄGG, G., "Die theoretischen Grundlagen der analytischen Chemie," 1st Swiss ed., Birkhäuser, Basel, **1950;** in Swedish: "Kemisk reaktionslära," 1st ed., Hugo Geber, Stockholm, **1940;** 4th ed., Uppsala, **1948.**
(4) BJERRUM, N., *Kgl Danske Videnskab. Selskab. Skrifter, naturvidenskab. math. Afdel.*, **12,** No. 7, 147 (1915).
(5) SILLÉN, L. G., *Acta Chem. Scand.* **3,** 539 (1949).
(6) Sjunde Nordiska Kemistmötet (seventh Nordic chemists' congress), Helsingfors 1950; paper read in Section I+II, Aug. 24, 1950; Abstracts p. 51.
(7) DELAHAY, P., M. POURBAIX, AND P. VAN RYSSELBERGHE, J. CHEM. EDUC., **27,** 683 (1950).
(8) POURBAIX, M., "Thermodynamique des Solutions Aqueuses Diluées," Meinema, Delft, **1945.**
(9) CHARLOT, G., "Théorie et Méthode Nouvelles d'Analyse Qualitative," 3rd ed., Masson, Paris, **1949.**
(10) LANGE, E., AND K. NAGEL, *Z. Elektrochem.* **42,** 51 (1936).
(11) HUEY, C. S., AND H. V. TARTAR, *J. Am. Chem. Soc.*, **56,** 2585 (1934).
(12) HEAL, H. G., *Trans. Faraday Soc.*, **45,** 1 (1949).
(13) HINDMAN, J. C., L. B. MAGNUSSON, AND T. J. LACHAPELLE, *J. Am. Chem. Soc.*, **71,** 687 (1949).
(14) KRAUS, K. A., Natl. Nuclear Energy Ser., Div. IV-14B, "The Transuranium Elements," Pt. I, 241 (1949).
(15) HAMMETT, L. P., "Physical Organic Chemistry," McGraw-Hill, New York, **1940,** p. 268.
(16) SCHWARZENBACH, G., AND R. SULZBERGER, *Helv. Chim. Acta*, **27,** 348 (1944).
(17) LUX, H., *Z. Naturforsch.*, **1,** 281 (1946).
(18) JØRGENSEN, H., "Redox-maalinger," Gjellerup, Copenhagen, **1945,** p. 10.

NOMINATIONS FOR JAMES FLACK NORRIS AWARD

THE James Flack Norris Award of the Northeastern Section of the American Chemical Society is made for outstanding achievement in the teaching of chemistry, particularly when demonstrated at college and secondary school levels rather than shown in the direction of research. The award is given in memory of James Flack Norris, himself an outstanding teacher, in accordance with a bequest from the late Mrs. Anne C. Norris to the Northeastern Section. It is granted biennially and consists of a sum of money and a scroll engrossed with an appropriate citation. The first was presented to George Shannon Forbes on May 10, 1951 (see J. CHEM. EDUC., **28,** 317 (1951).

Nominations for the second award, which is to be granted at the May Meeting in 1953, may be sent to any member of the following Canvassing Committee.

A nomination should be accompanied by ample supporting evidence of the achievement of the nominee and should be in the hands of the Canvassing Committee by Januray 2, 1953. The committee will shortly thereafter transmit the nominations to the Award Committee whose personnel is kept secret.

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Hubert N. Alyea, Frick Chemical Laboratory, Princeton University, Princeton, New Jersey.

Chester M. Alter, Dean of Graduate Students, Boston University, Boston, Massachusetts.

Edward R. Atkinson, Dewey and Almy Chemical Company, Cambridge, Massachusetts.

Henry E. Bent, Office of Dean of Graduate School, University of Missouri, Columbia, Missouri.

Fred L. Greenwood, Department of Chemistry, Tufts College, Medford 55, Massachusetts.

Eugene G. Rochow, Department of Chemistry, Harvard University, Cambridge, Massachusetts.

John A. Timm, Simmons College, Boston 15, Massachusetts.

Arthur A. Vernon, Northeastern University, 360 Huntington Avenue, Boston 15, Massachusetts.

William G. Young, Department of Chemistry, University of California at Los Angeles, California.

ARTHUR SIMON

RALPH E. OESPER
University of Cincinnati, Cincinnati, Ohio

Among the multifarious forms of chemical literature the abstract journals are probably the most useful. Their value is high with respect to both the current and older literature. The post of editor of one of the standard abstract journals carries much responsibility, and few men possess the peculiar combination of technical competence and administrative ability necessary for the successful publication of one of these important aids to the chemist. Arthur Simon edited the *Chemisches Zentralblatt* from 1945 to 1949, which indicates the caliber of this eminent German chemist, teacher, and writer.

(Johann Peter Caspar) Arthur Simon was born on February 25, 1893, at Barmen in the Wuppertal. He was trained under Baeyer at Munich and then under Windaus and Tammann at Göttingen, where he took his doctorate under Zsigmondy in 1920. After serving for a number of years as assistant to Wilke-Dorfürt at the Bergakademie in Clausthal, Dr. Simon habilitated as Privatdozent at Stuttgart in 1927, where he was named extraordinary professor in 1929. In 1932 he went to the Technische Hochschule in Dresden as successor to Fritz Foerster. At present he is ordinary professor and director of the Institut für anorganische und anorganisch-technische Chemie at this school, whose faculty has always had an excellent reputation.

His scientific output has covered a wide range. He began with a systematic study of the theory of affinity and dealt particularly with complex systems, oxides, and oxyhydrates. The use of the latter as catalysts or as their carriers led to a series of investigations on heterogeneous catalysis (catalysts for the preparation of motor fuels) and homogeneous catalysis (cell respiration, activity of spring waters, "active"iron).

Special equipment was developed for tensieudiometric studies. The various types of the Simon-Müller furnaces of the Staatliche Porzellanmanufaktur and the Simon cryostat and the Simon temperature regulator also demonstrate his abilities along instrumental lines. The work on the automatic cryostats was laureated with the Alexander Gutbier prize in 1929.

Parallel with these studies went investigations of the efflorescences on ceramic materials and frescoes. They led to methods of making these defects harmless or of preventing their appearance, an important factor in the preservation and protection of monuments and art objects (*e. g.*, the Schwind frescoes in the Wartburg).

The clarification of the causes of catalytic actions was carried out with the aid of the most modern methods, such as magnetochemical and Raman spectroscopic examinations. The theory of the skeleton-like oxidic catalyzers was developed. The general use, particularly of spectroscopic methods, led, especially through the use of heavy water, to the elucidation of the constitution of anhydrous acids, to the determination of structure in sulfur chemistry, hydrogen peroxide, and eventually of artificial materials. Insight was gained into the reaction between solvent and solute in solution systems. A projector was devised for the measurement of weak lines and a spherical cell for the photographing of solids by the Raman spectroscopic method. Special note should be made of the studies on biologically active iron and cobalt (against anemias) and the activity of spring waters, also of the researches dealing with homogeneous catalysis and the solid phases undergoing transformation as highly active intermediate phases in catalysis.

In order to free the aluminum industry from reliance on bauxite, processes were developed to utilize German waste clays, which had no value for refractories. Patents were granted for these processes and the methods found practical application. In this connection, mention should be made of the studies of electrolyte condensers, which led to a diffusion theory. There followed investigations of the oxide catalysts of the 8th, 1st, 2nd, and 3rd group of the periodic system, which are applicable for the removal of sulfur from coke-oven and illuminating gases and also for the catalytic combustion of carbon monoxide and hydrocyanic acid. Hence they were used in the German gas masks and eventually served in the manufacture of motor fuels.

In the field of metallurgy Professor Simon has concerned himself primarily with the problems related to the smelting of zinc. His researches have led to processes that prevent the formation of zinc ferrite, or that make it reducible in the muffle or extractable with alkali in the wet process. During this period he also made special studies of the absorption of carbon dioxide in non-alkaline media. In the metallurgy of silver, he showed that hydrogen peroxide is formed as an intermediate when the ores are extracted with cyanide. Other studies dealt with corrosion in sulfuric acid systems.

Many other investigations stemmed from his study of filtering phenomena. Recently, in addition to studies of catalysis in the solid state, he has been particularly concerned with Raman spectroscopy, studies that have resulted in the development of intense sextuple burners and the semiautomatization of the Raman spectroscopic procedure. He has worked out quantitative Raman spectroscopic procedures for the determination of insecticides (gammexane) and has advanced

the investigation of constitution of artificial materials. Among his studies in applied chemistry, emphasis can be placed on his studies of wood impregnation from oil phases and the fixing of sodium pentachlorophenolate in wood through bisulfite. He has worked out a number of streak procedures for determining chromic salts in wood in the presence of chromate, arsenate, and fluoride.

He has improved the ferromagnetic carrier of the magnetic recording tape and has prepared gamma ferric oxide, which has a smaller copying effect. Special mention should be made here of his procedure for determining the primary particle size, lattice defects, and faulty arrangements of ferromagnetics using X-rays.

These and many more researches have been recorded in about 150 papers. He has published monographs on tin, the Raman effect, and the constitution of the phosphorus acids. He collaborated in the Fehling "Handwörterbuch" and the *Jahrbuch* of the Verein Deutscher Ingenieure.

He has refused calls to Prague (1929), Graz (1931), Halle (1946), and Leipzig (1947). He is a member of the Academy of Sciences of Saxony, and in 1948 was invited to become a member of the governing board of the Deutsches Museum in Munich. In 1951 he was invited to deliver lectures on his special fields in Stockholm by the Academy of the Engineering Sciences. As stated above, he edited the *Chemisches Zentralblatt* from 1945 to 1949.

Full of original ideas and resourceful in translating them into research studies or putting them into technological practice, he is a credit to his profession.

ON IMPROVING THE LINGUISTIC SKILL OF STUDENTS

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THERE IS no denying that linguistic competence is deplorably lacking among college graduates. By this I do not mean competence in a *foreign* tongue; I mean command of rudimentary *English*, of the mechanics of communication, of syntax, grammar, sentence organization, spelling. Our technical graduates are particularly victimized by this, and industrial men as well as academicians are pained by the often semiliterate performance. The industrialists complain that our students write reports garbled in organization, grammatically meaningless, and atrociously spelled. The academicians know this to be pretty largely true, but if they complain they appear to do little about it. With the risk of heresy I dare to suggest that we, the teachers, are in part responsible—maybe in large part in the technical subjects. In truth, I fear in larger part than we care to admit! I believe that the widespread use of multiple-response quizzes and exams contributes to this linguistic inadequacy. Chemistry students and physics students can now pursue course after course without ever having to write a connected account of a topic. All they need do is pick out the right answer. The old-fashioned essay is dead. To ask for a return to the *classical* methods—writing essays and classroom recitation—will not meet with too promising approval. After all, multiple-response quizzes are elegant things to grade! How then can we aid the student's cause and not belabor our own? This brings me to the scheme I have now tried for several years and which has proved to have some measure of usefulness. *The students construct multiple-response questions.*

After I have administered a few multiple-response quizzes of my own coin (or the standard exams available on the market) I require the students to make out their own questions—statements followed by five completions, one of which is acceptable. Numerical problems are not used. Statements of theory, principle, fact, hypothesis, and so on, which can be put in good grammatical structure are what we want. This is no small order, as anyone who has made out multiple-choice quizzes will attest. It involves painstaking study of the point in question and very considerable labor in putting it into acceptable English. Finding five "good" answers (or completions), four of which are not correct but seem so, calls for some critical thinking. The exercise constitutes a magnificent review device but above all gives practice in the mother tongue.

These contributions I read with red pencil in hand. Acceptable ones I often use in subsequent quizzes! A competitive spirit often arises in class, which is itself a healthy concomitant to learning. Experience over several years shows that the subject is better commanded, and I believe I observe a substantial improvement in linguistic skill. The students themselves attest to the merits of the device—a recommendation *I* consider adequate.

SUGGESTIONS FOR DEMONSTRATIONS[1]

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Cathodic Protection of Iron from Corrosion. In 1824 Sir Humphry Davy first demonstrated the principle of the cathodic protection of metals from corrosion. This idea may be demonstrated before a class as follows: Half fill two 250-ml. beakers with tap water. Add a few drops of phenolphthalein to each. In one of the beakers stand a clean strip of iron (a strip measuring about 1 cm. by 15 cm. is satisfactory). Into the other beaker place a couple made by attaching a coil of freshly cleaned magnesium ribbon 25 cm. long to a strip of iron of the same size used in the first beaker.

The effect is evident within a few minutes and shows how an expendable anode of magnesium or aluminum may prevent local galvanic corrosion of ferrous metals, such as soil pipes and hot water storage tanks.

Use of Lithium in Preparing Hydrogen. Within the past decade metallic lithium has become available in a variety of forms, such as cup, rod, wire, ribbon, cartridge, and shot. Hydrogen may be conveniently and safely prepared by the action of lithium shot on water. Place about 15 shot in a 250-ml. wide-mouth bottle full of water, cover with a glass plate, immediately invert in a trough of water, and remove the glass plate. The lithium flame may be demonstrated by picking up a single shot with an ice pick and holding it in the non-luminous flame of the Bunsen burner. Diffusion in a solution may be shown by placing a few shot in a large cylinder of water to which some phenolphthalein has been added.

An Easily Constructed Conductivity Kit. Remove the switch from a plug-in bakelite night lamp. Rewire the lamp in series and attach alligator clamps to the plugs. Pencil leads are used as electrodes (Figure 1).

Support for Rubber Stoppers. A support for rubber stoppers (Figure 2) has been found useful, to make a few of any size or form readily available.

[1] Presented at the Symposium on Lecture Demonstrations at the 120th Meeting of the American Chemical Society, New York, September 7, 1951. For other papers in this symposium see THIS JOURNAL, **29**, 288 (1952).

Figure 1

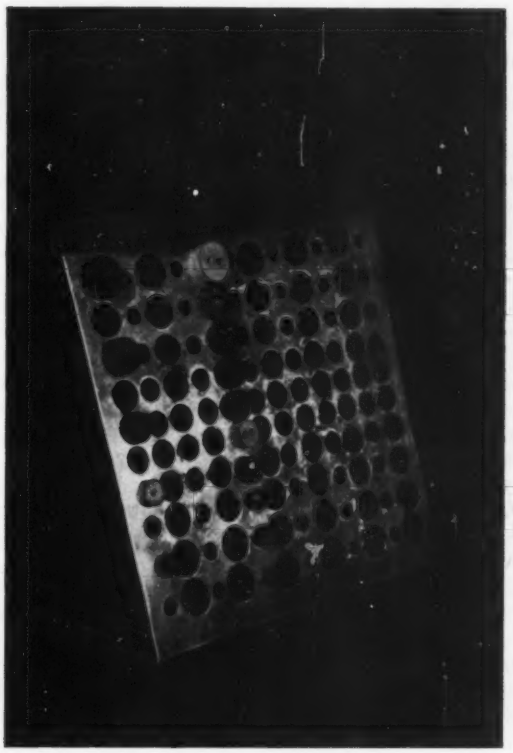

Figure 2

CHEMICAL ANALYSES IN THE SUBMICROMOLAR REGION[1]

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THE analysis of submicrogram amounts of material in "macro" volumes of solution (10–100 ml.) is a subject of increasing interest to the analytical chemist. An appreciation of the importance of trace elements has grown up in unrelated fields such as corrosion, where the rate of attack may be a function of the concentration of a minute impurity; fluophors, where hue and intensity of fluorescence is usually dependent upon the concentration of a trace component; radioactive tracers, where, to insure a high specific activity of a preparation, it is necessary to start with extremely pure materials; and biochemistry, where trace elements play a vital part in the growth of plants and animals as do physiologically active compounds such as enzymes and hormones. Although emission spectrography is very sensitive and applicable to many elements, it cannot, unfortunately, perform all the tasks that are required (particularly the determination of organic compounds) nor can it readily be applied by a nonspecialist.

"Ultramicroanalysis," a body of specialized techniques for handling submicrogram amounts of material in very small volumes of solution (less than 0.1 ml.) has been developed over a period of years, largely by biochemists, to solve particular analytical problems (*1*). However, the concentrations of the reagents and of the samples are usually the same as in the corresponding macro analysis. Thus, if a sample is very dilute, it must be concentrated to the point where it can be analyzed on the ultramicro scale. The time-consuming step of concentration could be eliminated in many cases if it were possible to run the analyses in extremely dilute solutions in the submicromolar region. In the case of samples which are already extremely tiny and hence have been handled by the ultramicro procedure, the availability of a suitable submicromolar method would allow the micro sample to be added to a large volume of solution and thereafter handled by an essentially macro procedure requiring a less specialized technique except for precautions against losses from sorption or addition of impurities through reagents, dust, or contaminated apparatus (*2*). Thereafter, it appears that there is ample justification for research on submicromolar methods.

In the discussion that follows, well-known techniques which are applicable to the submicromolar region will be considered first. Then a few promising but less familiar techniques will be outlined. For the sake of completeness, techniques for concentrating the material prior to analysis as well as some of the intermediate scaled-down methods which have not yet reached the highly specialized ultramicro level will be mentioned. No effort has been made to compile a complete bibliography, reference having been made only to review papers or to recent articles which illustrate a particular point in the discussion and, at the same time, contain a valuable list of pertinent references.

[1] Based upon a seminar presented at New York University on February 15, 1952.

DIRECT ANALYTICAL METHODS

The most obvious way to extend any procedure to handle smaller concentrations is to use a more sensitive reagent, and the historic search for more selective and more sensitive organic reagents for inorganic ions is well known. The introduction of organic reagents first offered a means of increasing the sensitivity by producing more insoluble precipitates having more favorable gravimetric factors. However, the sensitivity of the color-forming reactions together with the relative simplicity of making colorimetric analyses soon proved to be more fruitful. Despite the advent, since the last war, of more "fashionable" fields of interest, work in the field of organic reagents is still going on, and there is no reason to believe that valuable contributions will not be made for many years to come.

Another avenue for the extension of methods is through the use of improved instruments. For example, the photomultiplier tube for the measurement of radiation has opened up a means of making substantial improvements in fluorometric, flame photometric, and nephelometric methods because all of these involve the measurement of light intensities in a sample against a blank which ideally represents the absence of any light. Thus the limit of any of these methods depends, in principle, only upon the limit of the sensitivity of the detector. As an example of the sensitivity of fluorometric methods, one can point out that in aqueous solutions, concentrations of fluorescein as small as 10^{-4} per cent can be detected visually. Alternatively, one may sometimes add a portion of a submicromolar solution to a solid and note the fluorescence of the resulting bead. Such a procedure was reported for amounts of uranium as small as 10^{-10} g. using sodium fluoride as a flux (*3*). Similarly, in flame photometry, it has been possible to detect parts per billion of certain elements like sodium in solutions having volumes as small as 1 ml. In nephelometry, a familiar precipitate such as silver chloride can be used for solutions of silver as low as 10^{-8} *M* (*4*). In view

of the fact that commercial instruments which incorporate photomultipliers are now available in quantity, great strides should be made in all of these fields in the near future.

Although calorimetric methods do not usually come to mind in thinking about analytical chemistry, it appears that the availability of thermistors and of commercial amplifiers of high sensitivity justify reexamination of such methods. Reactions involving the generation of heat can be followed with ease to about the closest 0.005° C. Although thermistors must be used at relatively low temperatures (below 125° C.), thermocouples can be employed at higher as well as lower temperatures in conjunction with high sensitivity amplifiers to detect the same size of temperature change. Up to the present time there are no analytical examples to report except on a macro scale (*5*). Nevertheless the sensitivity has been clearly demonstrated in a recent study of the determination of small amounts of moisture in a stream of gas by measuring the temperature rise occasioned by reaction of the water with calcium hydride (*6*).

A series of interesting attacks on the submicromolar region are being made in polarography where the lower limit has usually been considered to be a concentration of 10^{-6} *M*. One approach is based upon the fact that increased area and rotation of an electrode each tend to increase the diffusion current. By placing 0.1 ml. of mercury in a cup and rotating at 200–800 r. p. m., concentrations of 10^{-8} *M* are placed within reach of an ordinary polarograph (*7*). On the other hand, if one wishes to use the conventional dropping mercury electrode, one group of investigators has shown that it is possible to perform a very accurate instrumental subtraction of the residual current which allows one to employ a much more sensitive galvanometer or recording potentiometer (*8*). Another investigator has taken advantage of the increase in sensitivity that results from an increase in the rate of change of potential by resorting to an oscillographic technique to measure current voltage changes at extremely fast rates of polarization (*9*). Although the last two instrumental approaches appear to be somewhat less sensitive than the rotating mercury electrode, they are known to be capable of reaching 10^{-7} *M* or less. Finally, there is the possibility of determining minute amounts of organic compounds which can depress polarographic maxima. In this way Kryukova has detected 10^{-9} mols per liter of surface-active agents and determined 10^{-8} mols per liter of 2-naphthol and 10^{-7} of octyl alcohol (*10*). Thus it appears that there are three avenues open for polarographic investigation in the submicromolar region.

One of the oldest, yet one of the least familiar, analytical techniques is coulometry. Despite the fact that coulometry has long been recognized as one of the most precise analytical methods for macro analysis, it has only been in the last fifteen years, and largely in the last five years, that people have appreciated the great promise of this technique in micro analysis (*11*). The potential sensitivity of this method is illustrated by the following calculation: assuming that an equivalent weight (one Faraday) is 10^5 amp. sec. the passage of one microampere for one second corresponds to 10^{-11} equivalents. Since the exact measurement of currents of one microampere presents no difficulty the use of much smaller currents is entirely feasible. For silver, which has an equivalent weight of about 100, 10^{-11} equivalents correspond to 10^{-9} g. For any volume greater than 0.01 ml. the concentration of silver in a solution will be less than 10^{-6} *M*.

One can apply Faraday's Law in two different ways. If one has a very dilute solution of an element which can be deposited electrolytically, deposition can be carried out without attempting to measure the extremely small current that passes through the cell. After the deposition, one can change the polarity of the electrode and measure the number of coulombs required to dissolve the deposit. In this way, millimicrogram amounts of silver have been determined to about 5 per cent (*12*). If the element cannot be deposited, but does undergo a redox reaction, it is often possible to generate coulometrically an appropriate oxidizing or reducing agent which will react with the element in question. Swift and his coworkers have played the leading role in this field (*13*). The amperometric end point as well as the potentiometric has been used by Furman and his associates (*14*) who have worked at the level of 10^{-12} equivalents. In principle, the coulometric generation of reagent is the more useful approach because it can handle organic reactions as well as inorganic.

Catalysis is another technique which, like coulometry, has only recently been recognized as a promising approach to analyses at the submicromolar level. Despite the fact that qualitative detection of a catalyst by its effect on the rate of an otherwise slow reaction has been known for a number of years for a variety of inorganic reactions, quantitative studies have been comparatively few in number (*15*). An excellent example is that of the determination of millimicrogram amounts of iodide by its catalytic effect on the ceric-arsenite reaction (*16*). The pioneering work in quantitative analysis has been done by biochemists whose attempts to determine enzymes by their catalytic behavior have been highly successful. Inhibition of an enzyme reaction has recently been employed to determine organic insecticides in millimicrogram amounts (*17*). Goto and his co-workers have led the "pure" analytical chemists for ten years in developing quantitative catalytic methods (*15*). Although variations are possible such as that in which a catalytic effect produces an abnormally large polarographic wave, (*18, 19, 20*) this appears to be somewhat limited compared to known reactions which can be measured spectrophotometrically. In any case, this field as a whole is relatively untouched, particularly by analytical chemists in this country.

Finally, there is the so-called "activation" method which depends upon the formation of a radio-

active nuclide from a trace element. The nuclide need not necessarily be that of the trace element as long as the latter is its source (*21*, *22*). Typical of analyses that have been reported by activation methods is that of arsenic in transistor preparations (*23*). In this case, bombardments were carried out on solid samples which, when dissolved, would produce concentrations of the trace element in the submicromolar region. While activation can, in principle, be applied to all elements, comparatively few can be analyzed in the millimicrogram range unless one has access to a nuclear reactor or a particle accelerator such as a cyclotron.

CONCENTRATION TECHNIQUES

Although evaporation is the most obvious method for concentrating a sample, the danger of losses through adsorption, volatility, and spattering make this method unattractive. On the other hand, a separation can serve not only to concentrate a substance but also to eliminate interferences prior to analysis (*24*). Thus a precipitation technique which has not been fully appreciated, is that of Clarke and Hermance (*25*) who first collected copper from very dilute solutions by passing them through paper impregnated with cadmium sulfide. Although cadmium, like copper, forms an insoluble sulfide, it is sufficiently more soluble to produce an adequate amount of sulfide ion to precipitate copper quantitatively.

In situations where the classical method of precipitation may be limited by failure to exceed a solubility product (*26*), one can often quantitatively coprecipitate such small amounts with a nonisotopic carrier. In recent years, the outstanding example has, of course, been the isolation of plutonium by coprecipitation with macro amounts of uranium. A less spectacular, though equally useful, application has been employed in spectrography where a number of heavy metals have been concentrated by coprecipitation with a mixture of ferric and aluminum 8-hydroxyquinolates (*27*). Finally, in activation analysis, which has been mentioned earlier, one almost never produces a single pure activity so separations of the radioactive nuclides often are made with the aid of carriers prior to counting.

Solvent extraction is probably the easiest and the most versatile of the separation methods and has been applied at both the macro and the ultramicro level. It can be applied with success to inorganic, organic, and organo-metallic systems (*24*). It offers the additional attraction that spectrophotometric or fluorimetric determinations can often be applied directly upon the extract with consequent savings in time. Unfortunately, even though it has no obvious limitation comparable to the solubility product in precipitation, one must proceed with caution in applying the data obtained from macro concentrations to very dilute solutions. As one goes to progressively more dilute solutions, competing equilibria may change the effective partition coefficient so much that in submicromolar concentrations the anticipated extraction (*26*) is very unfavorable. However, the same precautions appear to be in order for other separation techniques including electrolysis, volatilization, and chromatography (*26*).

Applications of chromatography and ion exchange have mushroomed since 1945, largely because they are readily adaptable for separations at the submicrogram level. Much of the impetus for ion exchange came from the separation and identification of promethium which was first done at the submicromolar level when it was present as a trace in a mixture of fission elements (*28*). More recently, paper chromatography has grown very popular for separating traces of substances both organic and inorganic although it is rarely used purely as a means of concentrating them (*29*).

SCALED-DOWN MACRO TECHNIQUES

At the beginning of this discussion, it was pointed out that methods which are available on a macro scale can usually be scaled down to smaller volumes. In most cases, there is much room for scaling down a macro procedure, particularly the instrumental ones, before highly specialized manipulative techniques of ultramicroanalysis become necessary. In polarography techniques for handling volumes of about 0.1 ml. appeared at a very early date (*30*). No special instrument or handling was necessary in this case although it was necessary to appreciate that losses of the trace element due to deposition could no longer be ignored. More recently, adaptations have been devised in spectrophotometry where a cell has been employed which has the usual length but an internal diameter of less than a millimeter. Although modifications may have to be made to the spectrophotometer such as collimating the light beam, the instrument and the overall technique are the same as for handling a macro sample. As a result, one can decrease the amount of element required for an analysis from the microgram to the millimicrogram level (*31*, *32*). It is obvious that other optical and electrical methods could likewise be scaled down. When the scale-down is performed on submicromolar procedures which are now being developed, the absolute quantities of substances that will suffice for an analysis will be of the order of 10^{-12} equivalents, an amount said to be in the range necessary for much biochemical research (*32*).

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LITERATURE CITED

(1) KIRK, P. L., "Quantitative Ultramicroanalysis," John Wiley and Sons, Inc., New York, **1950**.
(2) ROGERS, L. B., *Anal. Chem.*, **22**, 1386 (1950).
(3) HERNEGGER, F., AND B. KARLIK, *Sitzungsber. Akad. Wiss. Wien*, **144**, 217 (1935); through HADLEY, J. A., AND J. GRANT, "Fluorescence Analysis in Ultra-Violet Light," 3rd ed., D. Van Nostrand Co., Inc., New York, **1949**, p. 198.
(4) CAVE-BROWNE-CAVE, G., M. I. T. Thesis, Cambridge 39, Massachusetts, 1951.

(5) Willard, H. H., L. L. Merritt, Jr., and J. A. Dean, "Instrumental Methods of Analysis," 2nd ed., D. Van Nostrand Co., Inc., New York, 1951, p. 321.
(6) Harris, F. E., and L. K. Nash, *Anal. Chem.*, **23**, 736 (1951).
(7) Lee, T. S., Address before Chicago Section of American Chemical Society, November 23, 1951; through *Chem. Eng. News*, **29**, 5250 (1951).
(8) Kelley, M. T., and H. H. Miller, Atomic Energy Commission Report No. ORNL-842, January 15, 1952.
(9) Delahay, P., Address before the Analytical Symposium, Louisiana State University, January, 1951.
(10) Kryukova, I. A., *Zavodskaya Lab.*, **14**, 767 (1948); through *Chem. Abstracts*, **44**, 5757 (1949).
(11) Campbell, W. E., and U. B. Thomas, *Trans. Electrochem. Soc.*, **76**, 303 (1939).
(12) Lord, S. S., Jr., R. C. O'Neill, and L. B. Rogers, *Anal. Chem.*, **24**, 209 (1952).
(13) Buck, R. P., and E. H. Swift, *ibid.*, **24**, 499 (1952).
(14) Cooke, W. D., C. N. Reilly, and N. H. Furman, *ibid.*, **23**, 1662 (1952). See also pp. 896, 945.
(15) West, P. W., *ibid.*, **23**, 176 (1951).
(16) Lein, A., and N. Schwarz, *ibid.*, **23**, 1507 (1951).
(17) Giang, P. A., and S. A. Hall, *ibid.*, **23**, 1830 (1951).
(18) Kolthoff, I. M., and J. J. Lingane, "Polarography," Interscience Publishers, Inc., New York, **1941**, p. 199.
(19) Kolthoff, I. M., W. E. Harris, and G. Matsuyama, *J. Am. Chem. Soc.*, **66**, 1782 (1944).
(20) Haight, G. P., Jr., *Anal. Chem.*, **23**, 1505 (1951).
(21) Boyd, G. E., *ibid.*, **21**, 335 (1949).
(22) Leddicotte, G. W., and S. A. Reynolds, *Nucleonics*, **8** (3) 62 (1951).
(23) Smales, A. A., and B. D. Pate, *Anal. Chem.*, **24**, 717 (1952).
(24) Nachtrieb, N. H., "Principles and Practice of Spectrochemical Analysis," McGraw-Hill Book Co., Inc., New York, **1950**, p. 300.
(25) Clarke, B. L., and H. W. Hermance, *Ind. Eng. Chem., Anal. Ed.*, **10**, 591 (1938).
(26) Wahl, A. C., and N. A. Bonner, Editors, "Radioactivity Applied to Chemistry," chapter by N. A. Bonner and M. Kahn, John Wiley and Sons, Inc., New York, **1951**, p. 102.
(27) Mitchell, R. L., and R. O. Scott, *Spectrochim. Acta*, **3**, 367 (1948); through Reference 24.
(28) Marinsky, J. A., L. E. Glendennin, and C. D. Coryell, *J. Am. Chem. Soc.*, **69**, 2781 (1947).
(29) Strain, H. H., and G. W. Murphy, *Anal. Chem.*, **24**, 50 (1952).
(30) Majer, V., *Mikrochemie*, **18**, 74 (1935); through Reference 18, p. 245.
(31) Malmstrom, B. G., and D. Glick, *Anal. Chem.*, **23**, 1699 (1951).
(32) Kirk, P. L., Address before the 120th Meeting of the American Chemical Society in New York, September 1951.

A TECHNIQUE FOR HANDLING SMALL PRECIPITATES

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It is occasionally necessary to obtain in a form suitable for a melting-point determination amounts of precipitate too small to be collected on a filter paper. A common but tedious procedure involves centrifugation, removal of supernatant liquid with a micropipet, one or more washing operations, and drying of the residue in the centrifuge tube.

A more convenient and rapid technique requiring no special apparatus or experience is the following: The precipitate is allowed to settle in a 3-inch test tube, and all but a small amount (about one drop) of the supernatant liquid is removed by means of a dropper. The remaining drop of liquid is agitated to suspend the solid in it, the test tube is held at a small angle from the horizontal, and one end of a piece of capillary tubing 1.5–2.0 mm. in diameter and 100 mm. long is dipped into the suspension. Capillary action causes the suspension to be transferred entirely to the tubing of small diameter. The position of the column of liquid in the capillary tube can be readily controlled by very slight tilting of the tube from the horizontal.

A strip of filter paper about 3 mm. wide and 50 mm. long is rolled between the fingers along its length, and is inserted into one end of the capillary for a distance of about 15 mm.; the column of liquid being kept away from this end of the tube (the figure). The column of

Filter Paper Being Twisted into Capillary Tube

liquid is now slowly allowed to approach the edge of the filter paper while rotating the capillary tube. When the suspension touches the paper, the liquid gradually becomes absorbed, the solid collecting at the point of juncture. Washing of the precipitate is accomplished by dipping up some wash liquid, suspending the solid in it by rotating the capillary tube, and removing the liquid as above. The capillary and its contents may be allowed to dry in a desiccator, and then sealed at one end.

By this technique precipitates of the order of 0.1 mg. have been successfully transferred in easily visible form to melting point tubes.

CORRECTION OF BOILING POINTS FOR VARIATION IN BAROMETRIC PRESSURE

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CRAFTS's rule,[1] which can be written

$$T_b = T[1 + C(760 - p_{mm.})] \quad (1)$$

is much used in the organic chemistry laboratory to correct boiling points to one atmosphere. Crafts's constant, $C = RT_b/760\Delta H_{vap.} = (dt/dp_{mm.})_b/T_b$, has the value 0.00012 for substances that obey Trouton's rule. Crafts's rule was deduced from that of Ramsay and Young, and can also be derived, as is well known, from the Clapeyron-Clausius equation and Trouton's rule (in an approximate manner). The formula

$$T_b = T(1 - n \log p_{atm.}) = T[1 + n(2.8808 - \log p_{mm.})] \quad (2)$$

where $n =$

$$(T_c - T_b)/T_c \log p_{c\,atm.} = 2.303RT_b/\Delta H_{vap.} = 1750C$$

is more accurate than Crafts's rule. Comparison of equations 1 and 2 shows that Crafts's rule is an approximation of this formula. It will be derived below,[2] as will another useful formula. The constant n has the value 0.21 for substances that obey Trouton's rule. Values of n for water and various common types of organic compounds are given in the table.[3]

When van der Waals's vapor pressure equation

$$\log (p_c/p) = f(T_c/T - 1) \quad (3)$$

(where f is theoretically a universal constant but varies with the nature of the substance and even somewhat with temperature) is set up for a given substance at its normal boiling point and one other temperature, and the two equations are combined to eliminate $\log P_c$, the analogous expression

$$\log (p_b/p) = (fT_c/T_b)(T_b/T - 1) \quad (4)$$

results. It is readily rearranged to

$$T_b = T[1 + (T_b/fT_c) \log (p_b/p)] \quad (5)$$

which is equation 2 in another form. Equation (2) can be derived in other ways from equation 3, but the above derivation is briefest.

By noting the relationship between equation (3) and the integrated form of the Clapeyron-Clausius equation, it is seen that $fT_c/T_b = \Delta H_{vap.}/2.303RT_b$. (This expression appears in some textbooks; *e. g.*, S. Glasstone, "Textbook of Physical Chemistry," D. Van Nostrand Co., New York, **1946,** p. 457.) The other expression, $fT_c/T_b = [T_c/(T_c - T_b)] \log p_{c\,atm.}$, is readily derived from the van der Waals vapor pressure equation.

Note that equation 2 is equivalent to that of Wrede,

$$\log p = A - B/T \quad (6)$$

which is generally quite accurate for organic[4] liquids, and even solids, over a pressure range of several hundred millimeters.[5] (Because of this equivalence, values of n in the accompanying table can be used, if desired, to determine the vapor pressure-temperature behavior of pure organic substances over a fair range of pressure centering around one atmosphere; $A = 1/n$ if p is measured in atm. or $= 2.8808 + 1/n$ if p is in mm. of mercury, and $B = T_b/n$ in either case.)

There is an especial paucity of adequate data in the literature on even common compounds of the following types: aldehydes, acyl halides and anhydrides, alkyl fluorides (data for the other alkyl halides are frequently inconsistent, particularly in the case of the bromides), lactones, amines and sulfur compounds (the available data in these classes are few and highly inconsistent), amides, silicon compounds, compounds containing the CF_3 group, terpenes, heterocycles, and aromatics other than hydrocarbons, as well as phosphorus compounds.

It is apparent from the accompanying table that $1/nM$, which is proportional to the entropy of vaporization per gram at the boiling point, is, as a rule, related

[1] CRAFTS, J. M., *Ber.*, **20,** 709 (1887); *Compt. rend.*, **157,** 1403 (1913).

[2] It is related in form to several other equations, all of which are somewhat more complex. The closest relative is that of C. S. CRAGOE, *I. C. T.*, **3,** 246 (1928). Another near relative is $T_b = T(1 - m \ln p_{atm.})^{3/2}$, where $m = 3T_b/\ln \Delta H_{vap.}$, which was deduced by O. PILLING, *Physik. Z.*, **10,** 162 (1909), from known relationships, assuming in addition a continuous change of density between liquid and vapor.

[3] Though there are tables of Crafts's constant in the literature, they were assembled using older data than were used in compiling this table. It is a great pleasure to acknowledge the invaluable assistance of J. TIMMERMANS, "Physico-chemical Constants of Pure Organic Compounds," Elsevier Publ. Co., New York, **1950,** which was used as a source of data as much as possible. The general agreement between the various methods of calculation and between the values for adjacent members of homologous series was such that it is unwarranted to give n to more than two significant figures. In calculating n, less reliance was placed on $(T_c - T_b)/T_c \log p_{c\,atm.}$ than on $2.303RT_b/\Delta H_{vap.}$ and $1750(dt/dp_{mm.})_b/T_b$, because of the generally lesser reliability of critical data.—The author wishes that a work similar to Timmermans' would soon become available for inorganic compounds. This would be a profitable area for international cooperation which is so sorely needed nowadays.

[4] This equation is, of course, also applicable to volatile inorganic materials; *e. g.*, it holds so well for N_2 (and CH_4) all the way from its triple point to its critical point and for O_2 over an even wider range that a four-constant equation fits the data only slightly better (DODGE, B. F., AND H. N. DAVIS, *J. Am. Chem. Soc.* **49,** 610 (1927)).

[5] *E. g.*, see GERMANN, F. E. E., AND O. S. KNIGHT, *Ind. Eng. Chem.*, **26,** 467 (1934).

to the polarity of the corresponding molecule. The order of polarity in the alkyl halides is found to be Cl > Br > I, and $CHCl_3$ > CCl_4. Also in agreement with other studies is the finding that *cis*-crotonitrile is more polar than the *trans* isomer; and the methyl group in *p*-nitrotoluene depolarizes the nitro group to some extent. N-methyl- and N,N-dimethylaniline appear to be less polar than either aniline itself or any of the toluidines. It is interesting to note also that analogous benzene and thiophene compounds possess the same value of n, in harmony with other studies. Diethyl malonate is unusually low in the list for an ester, and this may be due to its chelate structure. The position of cyclopentanone and cyclohexanone is anomalous.

It may happen that a given compound is not listed in the accompanying table, and no analogies can be drawn with any compounds that are listed. In that case, it is, of course, still possible to calculate the normal boiling point, provided that boiling points are known at two different pressures instead of just one. This involves solving equations simultaneously. As this is tedious, it is done in general form below, to save labor in future specific numerical applications.

If the Wrede equation is applied at two temperatures, T and T', corresponding respectively to the pressures p and p', it is easy to show that

$$A = (T \log p - T' \log p')/(T - T') \qquad (7)$$

and

$$B = \log (p'/p)/(1/T - 1/T') \qquad (8)$$

If we write either one of these equations for a second set of temperatures and pressures, (T, p) and (T'', p''), and eliminate the constant, we obtain the result

$$T = [T'T'' \log (p'/p'')]/[T'' \log (p/p'') - T' \log (p/p')] \qquad (9)$$

which can also be written in the interesting form

$$\log (p'/p'')/T = \log (p/p'')/T' - \log (p/p')/T'' \qquad (10)$$

We can use equation (9) to calculate the normal boiling point of any substance if its boiling points at two different pressures are known; since no constants of any kind appear in the equation, it is fully general, within the limits of validity of the Wrede equation. (Of course, not only the normal boiling point but the boiling point at any pressure in the range for which the equation is valid can be calculated, if desired.) Because of its form, however, the greatest precision is obtained with pressures that are relatively far apart. This restricts its usefulness considerably; but it can be applied to relatively narrow ranges of pressure if the data are sufficiently precise. Two examples will serve to show this. Using the vapor pressure data of Schmidt[6] for benzene at 756.2 and 671.9 mm., a range of 84 mm., equation (9) give st_b = 80.17°; Schmidt found 80.15. Using the more precise data of Willingham, *et al.*,[7] at 779.34 and 732.07 mm., a much narrower range, equation (9) gives 80.104°; the value 80.103 was reported from their laboratory.

Values of n in Equation (2)

n	*Compounds*	
0.16	ROH, R = Am & Hx, incl. isomers	n-$HxCO_2H$
0.17	ROH, R = Me to Bu, incl. isomers	[n-$AmCO_2H$]
	Alicyclic alcohols	Cl_2CHCO_2H
	$ClCH_2CH_2OH$	ϕNO_2
0.18	CH_2=$CHCH_2OH$	H_2O
	ϕCH_2OH	RCO_2H, R = all isomers of Pr & Bu
	[ϕOH]	[ϕCO_2H]
	o-, *m*-, & *p*-MeC_6H_4OH	*p*-$MeC_6H_4NO_2$
	$OC(OEt)_2$	ϕCN
0.19	$HOCH_2CH_2OH$	HCO_2H
	RCO_2R', high M	$MeCO_2H$
	$(CO_2Et)_2$	Phthalic anhydride
	ArOR	[$(MeCO)_2O$]
	RCOR', open-chained, med. & high M	[ϕ_2NH]
	$RCO\phi$, med. M	2-Acetylthiophene
	$\phi CO\phi$	
0.20	RCO_2R', low & med. M	$Si(OEt)_4$
	ϕCO_2R, R = Me & Et	[RNH_2, $RNHR'$, $RR'R''N$, low & med. M]
	o-$HOC_6H_4CO_2Me$	ϕNH_2
	ROR', open-chained & cyclic, med. & high M	*o*-, *m*-, & *p*-$MeC_6H_4NH_2$
	Furfural	CH_2=$CHCH_2CN$
	ϕCHO	[Et_2S]
	RCOR', low M	[Anthracene]
	[Cyclopentanone]	[Phenanthrene]
	[Cyclohexanone]	
	$CHCl_3$, $CHBr_3$	
	[RX, X = Cl, Br; R = Me to Oc, incl. isomers]	
	ϕF	
0.21	ROR', open-chained & cyclic, low M	$SiMe_4$
	$RCH(OR')_2$, low M	$\phi NHMe$, ϕNMe_2
	n-HxCHO	$MeNO_2$
	RI, R = Me to Oc, incl. isomers	RCN, low & med. M; no data for high M
	[CH_2Cl_2, CH_2Br_2]	*cis*-MeCH=CHCN
	[$ClCH_2CH_2Cl$],	$(CN)_2$
	$BrCH_2CH_2Br$	Thiophene
	[CH_3CHCl_2]	2- & 3-Me-Thiophene
	CCl_4	ϕR, R = H to *n*-Bu, incl. *i*-Pr
	ϕX, X = Cl, Br, I	*o*-, *m*-, & *p*-$C_6H_4Me_2$
	[*o*-$C_6H_4Cl_2$]	ϕ_2
		Hydrocarbons, aliph., high M
0.22	$CH_2(CO_2Et)_2$	*trans*-MeCH=CHCN
	$COCl_2$	Hydrocarbons, satd. & unsatd., open-chained cyclic, med. M
0.23	[MeCHO]	CS_2
	[MeCOCl]	Hydrocarbons, satd. & unsatd., open-chained & cyclic, low M (except propane & lower)
	CH_2=$CHCH_2Cl$	

Note: The terms low, medium, and high molecular weight are defined as follows: low—when the sum of the numbers of C, O, and N atoms is ≤ 6; med.—$6 < \Sigma(C, O, N) \leq 12$; high—$\Sigma(C, O, N) > 12$. The various alkyl groups are designated by their usual symbols, in addition to which Hx and Oc are used to mean hexyl and octyl. Compounds whose locations in the table are not fully certain, owing to the inconsistency of the available data, are enclosed in square brackets. Alcohols, ethers, aldehydes, ketones, esters, and alkyl and acyl halides are listed in the left-hand column of the table, while hydrocarbons, carboxylic acids, and acid anhydrides and nitrogen, sulfur, and silicon compounds are listed in the right-hand column.

[6] Schmidt, M., Thesis, Paris, 1934; via Timmermans, *loc. cit.*, p. 142.

[7] Willingham, C. B., W. J. Taylor, J. M. Pignocco, and F. D. Rossini, *J. Research Nat. Bur. Standards*, **35**, 219 (1945).

PHOTOMICROGRAPHY AS A TOOL FOR TEACHING COLLOID CHEMISTRY

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ONE of the greatest problems faced by an educator who is responsible for imbuing college or university students or students of technological institutes with the fundamentals of colloid science is the need for offering as many visual demonstrations of the colloidal state of matter as possible. Based on many years of experience of one of us (E.A.H.) in teaching colloid chemistry, it must be admitted that the most effective way is to apply Samuel John Stone's words, "What I can't see, I never will believe in," to such courses. This is of primary importance in trying to explain that what we today term "colloids" does not refer to specific compounds but to a specific *state* of matter.

Thomas Graham, who coined the word "colloids," differentiated between them and crystalloids according to the diffusivity of their solutions.[1] A. Mueller[2] proposed a division into suspensions of fine particles and solutions of high molecular compounds. H. Bechhold[3] even differentiated between organic and inorganic colloids. Depending on the point of view taken by various authors, colloids were considered as belonging either to the group of mechanical suspensions or to molecular solutions. A typical dualistic point of view resulted. Not until 1906 was the "disperse state of matter" as the general point of view introduced by Wolfgang Ostwald,[4] the colloidal state being one step in the series extending from matter in the coarse state through microscopically detectable dispersions to the colloidal state and further down to truly molecular solutions. In his book, "The World of Neglected Dimensions,"[5] Ostwald summed up his point of view in the following statement: "Modern colloid chemistry teaches that there are no sharp differences between mechanical suspensions, colloid solutions and molecular solutions. There is gradual and continuous transition from the first through the second to the third. Mechanical suspensions, colloidal solutions and molecular or true solutions have the dispersed state in common."

Entirely independent of Ostwald's primarily theoretical deductions, the Russian scientist, P. P. von Weimarn, offered the necessary experimental proof for Ostwald's statement during 1905 to 1907.[6] Studying the reaction

$$MnSO_4 + Ba(CNS)_2 + aq. = Mn(CNS)_2 + BaSO_4 + aq.$$

he found that the consistency in which the insoluble barium sulfate precipitated depended entirely on the concentration of the reacting solutions.

On the basis of over 200 experiments he found that it was always possible to obtain extremely fine crystals, coarse flocks, or jellies, which upon dilution formed colloidal sols, depending only on the concentration of the reacting substances used. Von Weimarn summed up this first important experimental contribution to colloid chemistry in the following statements: "The so-called colloidal, amorphous and crystalloidal states are all together universal (possible) properties of matter. . . . Generally speaking, it follows from these investigations that colloids and crystalloids are by no means two special worlds but that there exist close relations between themselves as well as between them and the gaseous and liquid states of matter."[6]

This contribution is today known as "von Weimarn's Law of Precipitation." It is beyond any question of a doubt one of the greatest contributions to the development of modern colloid science and therefore its teaching deserves special attention.

Our experience has proved that classroom demonstration of the von Weimarn Law of Precipitation carries with it serious drawbacks. The procedure is time-consuming. It is necessary to set up three filtration funnels equipped with quantitative filter paper, make up three solutions with different concentrations of reacting chemicals and then subject the formed dispersions to filtration. All equipment must be perfectly clean and the water used for making up the solutions absolutely electrolyte-free. But even with the greatest precautions one never can obtain as clear-cut a differentiation as one would wish between the reaction product obtained with the greatest dilutions and that with the highest concentration. Although the residues left

[1] GRAHAM, TH., *Phil. Trans. Roy. Soc.*, **151**, 183 (1861); *Proc. Roy. Soc.*, **13**, 335 (1864).
[2] MUELLER, A., *Zeit. anorg. Chem.*, **36**, 340 (1903).
[3] BECHHOLD, H., *Zeit. physikal. Chem.*, **48**, 385 (1904).
[4] HAUSER, E. A., "Colloidal Phenomena," McGraw-Hill Book Co., Inc., New York, **1939**, pp. 1–25.
[5] OSTWALD, WO., *Koll. Zeit.*, **1**, 291, 331 (1906); "An Introduction to Theoretical and Applied Colloid Chemistry," 2nd ed., John Wiley & Sons, Inc., New York, **1922**, p. 14.
[6] VON WEIMARN, P. P., *J. Russ. Physiko-chem. Ges.*, **37**, 949 (1905); *Koll. Zeit.*, **2**, 76, 128, 199, 230 (1907); **3**, 282 (1908); **4**, 27, 123, 198, 252, 315 (1909); **5**, 62, 117, 150, 212 (1910).

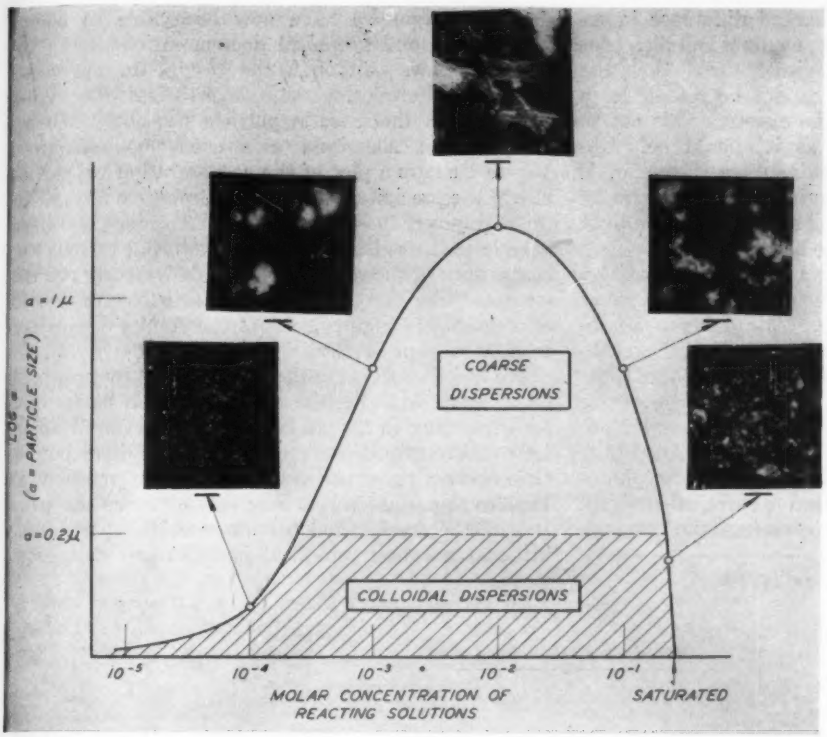

Figure 1

The von Weimarn Law of Precipitation Curve Illustrated with Photomicrographs. Original Magnification 550×

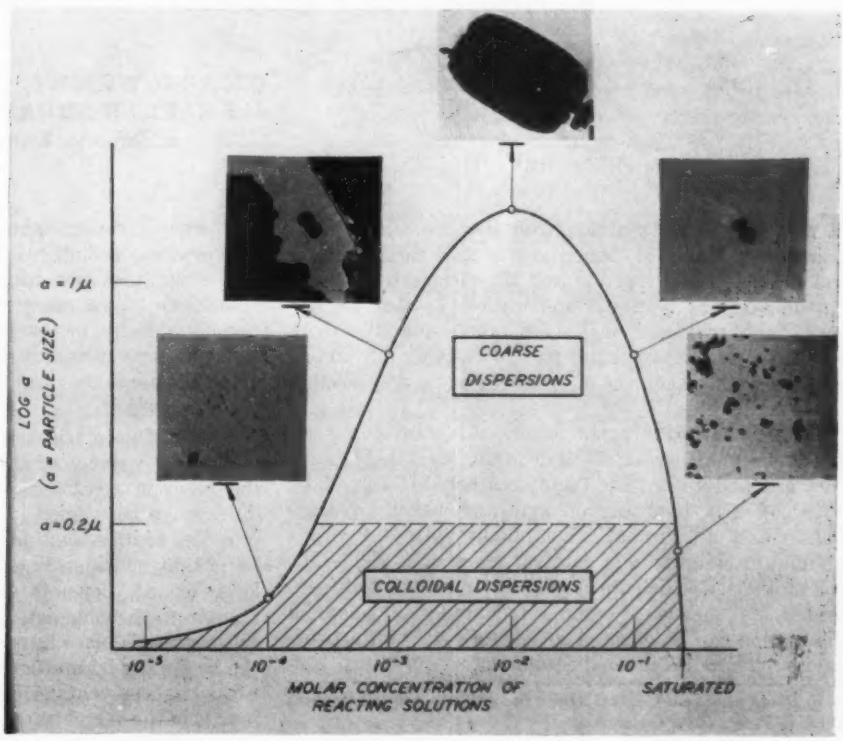

Figure 2

The von Weimarn Law of Precipitation Curve Illustrated with Electron-Photomicrographs. Original Magnification 9,500×

on the filter papers show a marked difference in retained material between the low, medium and high concentrations, thereby offering visual proof that the colloidal range of dimensions cannot be set off by a straight line of demarcation, the experiment is not so convincing to the newcomer as it should be. Unquestionably the greatest disadvantage, however, is the time lost while this experiment is in progress; under our prevailing educational setup every minute at our disposal must be used to the best advantage.

We therefore decided to offer a visual demonstration of the von Weimarn Law of Precipitation by the use of ultra- and electron-microscopy. The electron microscope has already been applied successfully in the teaching of science,[7] providing direct observation of phenomena previously known only by indirect means. One of us (H.E.B.), jointly with Prof. Solari and Prof. Catoggio of the University of La Plata in Argentina, has already successfully used Fischer's electron photomicrographs in teaching quantitative chemical analysis. By the use of the electron microscope and the Ultropak ultramicroscope we have now been able to offer a very simple and graphical demonstration of the von Weimarn law. Although the results do not reveal any new information they nevertheless offer visual proof of the difference in particle size obtained when reacting the chemicals at various concentrations. Figure 1 shows a plot of the concentration vs. particle size of the precipitate and at the same time ultraphotomicrographs of these precipitates. Although the difference in particle sizes obtained when using various concentrations of the reacting chemicals is clearly evident, we also subjected the precipitates to electron-photomicrography. Figure 2 shows the results of the electron-microscope studies.

We feel that showing these two figures by projection on a screen will give the teacher a much better basis for explaining to his students what the von Weimarn Law of Precipitation stands for than to carry out the time-consuming experiments previously referred to. Besides this, the student may now even see the structure of the precipitated particle, something which has hitherto not been practical in classroom demonstrations.

[7] FISCHER, R. B., J. CHEM. EDUC., 24, 484 (1947).

THE FRIEDEL-CRAFTS REACTION IN ELEMENTARY ORGANIC LABORATORIES

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Two very common reactions from the theoretical standpoint in the study of elementary organic chemistry are the Friedel-Crafts reaction and the Grignard reaction. In the study of synthetic preparations of alcohols, ketones, and hydrocarbons, these organo-metallic reactions play a most important part. Yet very few undergraduate college courses offer laboratory work utilizing these procedures.

The fire hazard inherent in procedures involving the use of ether and carbon disulfide in the beginning laboratory is a well-known and highly respected factor. The Friedel-Crafts hydrocarbon synthesis using an alkyl halide and an aromatic compound with anhydrous aluminum chloride as a catalyst gives poor yields, for the most part, which are usually mixtures not easily separated by means of simple techniques. Fractional distillation can be effected successfully only if the process is well handled in good equipment.

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The acylation procedures recorded in various laboratory manuals and other literature also call for apparatus and techniques not usually found in the beginning laboratory, since many procedures call for extended periods of reflux or reaction time. Not all courses include reduced pressure distillation techniques, either, and their use is essential to many preparations listed in the literature.

Yields of aromatic ketones are recorded as between 80 and 90 per cent of the theoretical, depending upon the reaction conditions. Many deviations of procedures have been tried in order to improve yields; for purposes of investigation the yield of any product is an important consideration. The yield of product, to a large extent, depends upon the techniques and the ability of the chemist, however, and even though a great stress is placed upon the mastery of technique in the beginning laboratory, it is definitely a limiting factor. High percentage yields are not essential to good results in the achievement of the aims of student labora-

tory work; nor is the handling of large amounts of various species.

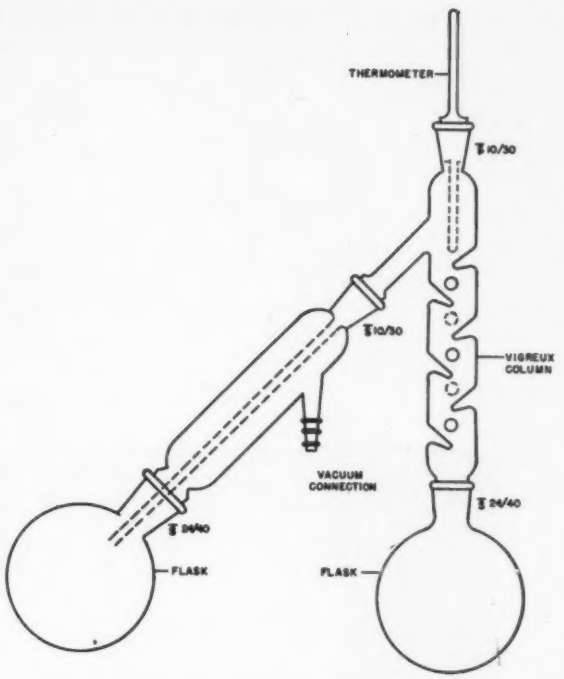
Budgets are usually the initial consideration in the selection of experiments to be done in all elementary laboratories, especially in small schools. It was with this thought in mind that we began to search the literature for experiments utilizing small, inexpensive equipment and semimicro techniques. Much can be said for the acquisition of fine techniques made possible by the efficient handling of small amounts of material. We have used many semimicro procedures in our laboratory experiments this year with a high degree of success.

One of the procedures we used is a modification of the Perrier ketone synthesis, although it works just as well in the normal acylation reaction procedure. This reaction is run in an 8-inch test tube, without drying tubes, without condenser, without automatic stirring, and without gas trap. The reaction is run in 0.1-molar quantities (or smaller) and the time is reduced greatly. The use of small quantities diminishes the fire hazard. The washing of the product is as customary. The product is distilled in a small distilling flask at atmospheric pressure, using a Bunsen flame as a source of heat. The product is collected in a weighed test tube. Yields of product in this reaction run as high as 85 per cent.

Aromatic compound	*Acylating agent*	*Yield, g.*	*Yield, %*
Benzene	Acetyl chloride	7.9	66
Benzene	Propionyl chloride	8.3	62
Benzene	Butyryl chloride	10.4	70
Benzene	Benzoyl chloride	7.8	43
Toluene	Acetyl chloride	8.8	66
Ethylbenzene	Acetyl chloride	9.0	61
Cumene	Acetyl chloride	11.4	70
Cumene	Propionyl chloride	12.7	72
Cumene	Butyryl chloride	14.3	75
sec-Butylbenzene	Acetyl chloride	10.5	60
sec-Butylbenzene	Propionyl chloride	12.0	63
sec-Butylbenzene	Butyryl chloride	14.7	72
p-Cymene	Acetyl chloride	9.0	40
Bromobenzene	Acetyl chloride	10.2	50
o-Dichlorobenzene	Acetyl chloride	9.6	51
o-Bromotoluene	Acetyl chloride	16.8	84
Diphenyl ether	Acetyl chloride	6.6	31
Anisole	Acetyl chloride	8.0	53
Anethole	Acetyl chloride	Polymerized	
Pyrrole	Acetyl chloride	Polymerized	

The yields given in the table above were obtained by beginning students in the elementary organic course. They no doubt could be improved on by an experienced investigator, but they show the type of work which is possible by the student in an elementary course.

This modification of the Friedel-Crafts acylation reaction reduces the time element, the cost (by using smaller quantities), the fire hazard, and eliminates the use of expensive equipment, thus making its use practical in the elementary course. Any or all of the aluminum chloride complexes may be isolated if desired. All of the details of the reaction may be observed during the process. Where it is possible, reduced pressure techniques may be employed. The apparatus used in this laboratory for reduced pressure distillation can be made with but little glass-blowing technique (see the figure).



The experimental procedure is as follows: Weigh 16 g. (0.12 mol) of anhydrous aluminum chloride into a dry, 8-inch test tube. Add 15 ml. of carbon bisulfide and stir with a glass rod until the suspension is uniform. Cool the mixture in an ice-water bath, and add slowly 7.85 g. (0.1 mol) of acetyl chloride. Some effervescence of HCl may be noted here, and unless efficient cooling is effected, some of the carbon bisulfide may boil out. After this mixture has been stirred and cooled thoroughly (5–10°C.) add slowly from a dropping funnel 10–15 ml. (excess) benzene. (Dry benzene will improve the yield but is not essential.) If no reaction is apparent at this point the reaction mixture may be removed from the cooling bath and allowed to warm to room temperature; with some compounds it may be necessary to warm in a hot-water bath. It may be necessary to replace the test tube in the cooling bath if the reaction shows signs of boiling out of the tube. The reaction is usually complete in 10–15 minutes and is immediately poured into a mixture of HCl and crushed ice, separated, and the aqueous solution extracted twice with 10-ml. portions of ether. The oil and ether extracts are combined, washed once with water, once with 10 per cent sodium carbonate solution, and twice again with water. The ether extract is then dried with a few granules of calcium chloride and distilled. The fraction boiling from 180° to 210° is collected and, if purity is desired, redistilled. Derivatives may be prepared from the cut after one distillation. The 2,4-dinitrophenylhydrazone is especially convenient in the case of acetophenone. The yield of acetophenone is 8–10 g.

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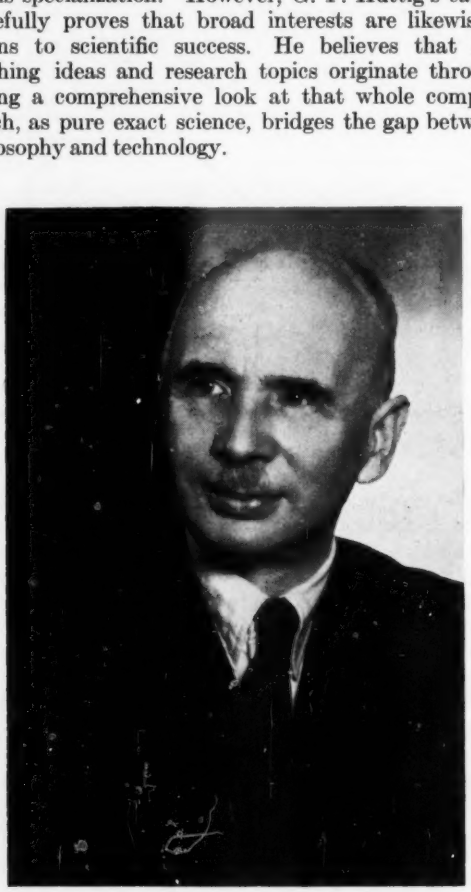
To many the dominant characteristic of the present age is specialization. However, G. F. Hüttig's career forcefully proves that broad interests are likewise a means to scientific success. He believes that far-reaching ideas and research topics originate through taking a comprehensive look at that whole complex which, as pure exact science, bridges the gap between philosophy and technology.



Gustav F. Hüttig

The printed record of his life work is contained chiefly in more than 400 papers in most of the important chemical periodicals. At an early stage in his career, and under the influence of Wilhelm Biltz, he became interested in the theory of chemical affinity and the chemistry of complex compounds. Especially through extensive studies of the ammines of metal halides, he arrived at a quantitative geometrical basis of the maximum coordination number. In this connection he developed his "tensieudiometer," a device that permits the simultaneous measurement of the pressure and volume of gases. Next, via the investigation of the hydrates of salts, he went into the question of oxyhydrates, a field of study that was rounded off by the publication (with R. Fricke) of "Hydroxide und Oxyde" (Leipzig, 1937; reprinted Ann Arbor, 1944, 625 pages). He discussed at length the various types of water binding, and in particular showed that the osmotic binding of water in solids (one of his discoveries) is subject to the same laws that hold for the osmotic phenomena in liquid solutions. The stoichiometric chemical binding of water, as well as solid solution, osmotic binding, binding in capillaries, and finally adsorption are the ideal limiting cases, compared with which the realizable instances must be designated as transition stages between such limiting cases. By extension of the studies to other classes of materials, the fact emerged that the law of constant and multiple proportions for solids is a limit law that is never attained as is the case, for example, with the ideal Boyle-Gay-Lussac law for the behavior of real gases.

Hüttig's observations and formulations concerning "vagabundieren" lattice constituents, *i. e.*, constituents that wander about in the crystal lattice, deal with the same phenomenon which was subsequently discussed in detail by others as crystal lattice self-diffusion. Such phenomena permit the recognition that the corner stones of the actual happening are the mass action law, which holds for the ideally freely mobile molecules on one hand and the Gibbsian phase rule that is valid for those that have fixed positions in solids. Particularly intensive studies were made of the thermodynamics and kinetics of the reactions of the types:

$$\mathrm{AB\,(solid)} \rightarrow \mathrm{A(solid)} + \mathrm{B(gaseous)}$$

and

$$\mathrm{A(solid)} + \mathrm{B(gaseous)} \rightarrow \mathrm{AB(solid)}$$

It was found that there is a continuous series of "activated" states, which in some instances can be prepared in isolable form, between the arrangement of the molecules in the starting materials and the end products. The strikingly high activity of the molecules situated in the interfaces is the cause of the observed thermodynamic equilibria, the kinetic behavior and also of the catalytic activity. The multiplicity of intermediate states that can be produced in the laboratory or plant has special interest for technical catalytic processes. Many of those who heard Professor Hüttig lecture on catalysis and related topics in 1936 at Madison, Minneapolis, Ames, Lafayette, etc., undoubtedly recall the strikingly clear presentations of this complex subject, lectures highlighted by such expressions as "principle of the betrayed betrayer," "switch effect," and "power of memory of solids."

During the past ten years, he has devoted himself to an amazingly wide range of topics: adsorption;

the use of aluminum silicates as a source of this metal; the electromagnetic properties of solids; the effect of the surrounding medium on the electrical conductivity of very thin wires; metal carbides; the systematization of chemical reaction types, etc. He has given special attention to pulverizing techniques and powder metallurgy. In fact, his latest visit (1949) to this country was as a powder metallurgist; he gave a lecture on this subject at Bayside, New York. Since sintered or fritted materials have many more degrees of freedom than true stable chemical compounds with respect to combinations of different properties, they provide a source of technical materials that as yet has been far from being fully exploited for either scientific or manufacturing purposes.

Gustav France Hüttig was born on May 13, 1890, at Prague, where his ancestors had lived for centuries. He was trained at the Deutsche Technische Hochschule there. From 1914 to 1926 he was assistant and then (1921) Privatdozent at the Bergakademie in Clausthal. In 1922 he was called to the University of Jena as professor of inorganic and physical chemistry. During World War I he served (finally as lieutenant) in the Austro-Hungarian army. He returned to his native Prague, where he was director of the Institut für anorganische und analytische Chemie at his alma mater from 1926 to 1945. He was then driven out, stripped of all his possessions. However, he soon was called to his present post, director of the laboratory of inorganic and analytical chemistry at the Technische Hochschule in Graz.

Professor Hüttig is a member of various European scientific academies and also of the Vienna Academy. In 1936 he received the coveted Liebig Medal of the Verein Deutscher Chemiker. He is one of the editors of the "Monatshefte für Chemie." He compiled a large portion of his work in the "Handbuch der Katalyse," Volume VI, 318–578, Vienna, 1943. He has also made significant contributions to W. E. Kingston's "The Physics of Powder Metallurgy" (New York, 1951) and to the "Powder Metallurgy Bulletin," issued by P. Schwarzkopf at Yonkers, New York.

MICRO-BUMP-ROCKETS

A Demonstration of the Power of Superheated Liquids

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SOME time ago, while investigating properties of superheated liquids, the writer devised a demonstration for undergraduate chemistry laboratory students which dramatically illustrates the energy stored in superheated liquids and points up the danger of heating liquids such as ethyl ether in the laboratory without suitable precautions to prevent "bumping." In essence the experiment utilizes the energy stored in a small amount of superheated liquid to propel a small rocket made of a glass melting-point tube.

The melting-point tubes, like those used by organic chemists, are made by heating the center portion of a small soft-glass test tube in a bunsen flame and drawing the tube out into a capillary about $1^1/_2$ mm. in diameter. From this long capillary tube straight sections 6 to 7 cm. long may be broken out, using a sharp file. Each section should then be closed at one end by momentarily holding it in the edge of a flame.

By use of a medicine dropper, the end of which has been drawn out into a fine capillary which can be introduced into the melting-point tube, the rocket may be filled about three-fourths full of ether. Care should be taken that the closed end is filled completely with the ether. Bubbles can be removed by using the medicine dropper.

For a launching tube use a 15-cm. length of Pyrex thick-walled capillary tubing (like barometer tubing). This may be clamped in a support at any suitable angle. The rocket should fit very loosely in the launching tube. The ether-filled rocket is introduced into the lower end of the launching tube. The open end of the rocket should project slightly from the lower end of the launching tube.

By gently heating the exterior of the launching tube with a small flame, the ether in the rocket can be highly superheated. By close observation, the ether in the

rocket may be seen to expand until it reaches the rocket's open end, at which time, with a noise like a pistol shot, the rocket "takes off" with tremendous speed. The writer has achieved flights of 40–50 feet with these microrockets, which with a little good luck may be recovered and used again.

If the rocket is halted by sharply striking a wall, etc., before its fuel is used up it will explode with a loud "bang."

Water may be used to fuel these micro-bump-rockets; however, the rocket tube must be boiled (closed end up) in the water for about 20 minutes immediately prior to using, during which it will gradually fill with water. Final adjustments of the water level (using the boiled water), removal of bubbles, etc., are easily accomplished using the medicine dropper previously described.

The demonstration should be done only by one experienced in laboratory operations and should be considered as hazardous. While the writer has never experienced any difficulties, the demonstrator should wear safety goggles or other eye protection and the rocket launching site should be guarded by safetyglass shields. Spectators obviously should be kept from in front of the rocket and at a safe distance from the rocket when fired. And, of course, when fueling the ether rocket and when handling ether there must be no flames in the vicinity.

A DIAGNOSTIC TEST IN SIMPLE MATHEMATICS

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HIGH-SCHOOL administrators and teachers of mathematics are in general quite unaware of the kind of mathematics preparation necessary for those students who are going to the colleges and universities for the purpose of studying in the physical sciences. The majority intend to take the premedical curriculum with a scattering in chemistry and physics as their major subject. Those who do elect the course prescribed by the medical schools will take primarily general chemistry, qualitative analysis, quantitative analysis, and organic chemistry.

The first three of these subjects require much arithmetic, a fair amount of algebra, and the use of logarithms and exponentials. Even the reasoning in portions of organic chemistry is mathematical in nature, requiring the same logic as does plane geometry. The authors feel therefore that there is a close correlation between a student's performance in mathematics and his ability to think chemically.

In order to have a talking point with the counselors of the high schools and aid in advising the student in the first-year courses, we have devised a simple test in mathematics. We talk over the results of the test with each individual student who does poorly and suggest means of improving his technique in handling the processes in which he is weak.

Students in the beginning courses in chemistry have their greatest difficulties with problems involving the gas laws, concentrations of solutions, and equilibria involving ions. Students generally fail not from a lack of understanding of the principles involved but from inability to handle the so-called "math" involved.

We have found the test in simple mathematics valuable in diagnosing the student's mathematical troubles and indicating specifically where he needs help. Reports have been given to the State's Association of High School Mathematics Teachers and they have cooperated with us in giving the prospective student of the physical sciences a better background. The complete test, with a total of 20 questions, is given in 45 minutes and can be arranged for use in an IBM machine or hand-corrected. An illustrative sample of the questions is given below.

(1) Which number is *larger* than 2.4×10^{-6}? 24×10^{-7}, 2.5×10^{-6}, 65×10^{-7}, 2.0×10^{-14}, 2.3×10^{-6}.

(2) The logarithm to base 10 of 1/1000 is: 1000, −3.0, −2.0, 4.0, 10.4.

(3) $\frac{1 \times 10^{-6}(x)}{1 \times 10^{-12}} = 1 \times 10^{-6}$. Calculate x. 3×10^{-14}, 1×10^{-18}, 1×10^{18}, 1×10^{-14}, 2×10^{-6}.

(4) The cube root of 2.7×10^{-2} is: 3×10^{-2}, 4×10^{-2}, 3×10^{-1}, 9×10^{-1}, 3×10^{-6}.

(5) Find x if the ratio of x to $^1/_2$ is 50 to 1. 1000, 200, 100, 50, 25.

(6) $x^2 + 0.15x - 2.53 = 0$, x equals: +1.68, −1.68; +2.86, −3.85; +1.52, −1.67; +4.38, −2.93; +1, −2.

(7) If $\log_a M = x$, then M equals: x^a, M^x, a^x, x/M, M/x.

(8) If a team wins 2 games and loses 8, what per cent are won? 25%, 2%, 20%, 2.5%, 0.2%.

AN AUTOMATIC CONSTANT-VOLUME FRACTION COLLECTOR[1]

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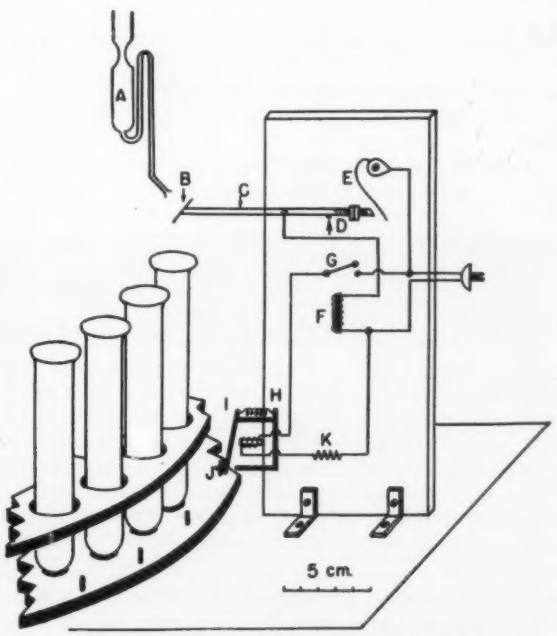
THE widespread use of chromatographic and ion exchange columns has established the need for automatic fraction collecting devices. To supply this need in our laboratory an inexpensive constant volume fraction collector has been designed.

Various types of automatic fraction collectors have already been described (*1–8*). Those employing electronic units cannot be considered if initial expense and maintenance are primary factors in determining the choice of a fraction collector. If an inexpensive unit is to be satisfactory it must have a positive and reliable action, deliver fractions of constant volume and involve no features of assembly or adjustment that cannot be handled by ordinary laboratory personnel.

The apparatus in use in our laboratory employs an intermittent siphon as a fraction cutter, and a simple electrical mechanism controlling the position of the receiver rack which is mounted on a spring-driven phonograph turntable. The apparatus is sketched in the accompanying diagram.

The manner in which the liquid is delivered from intermittent siphon *A* activates the control mechanism. The bulk of the liquid falls vertically from the delivery tube *directly* into the receiver. The last few drops emerge with increased velocity and strike paddle *B* before falling into the receiver. *C* is a copper bar 3 × 3 × 110 mm. supported by a steel needle through a hole at the approximate balance point and resting on pin *D*. The sensitivity of the movement of *C* about the fulcrum is controlled by adjusting the nuts at the threaded end. The force against *B* elevates the threaded end of *C* making a brushing contact with *E* (the copper conducting strip of the cam-activated part of a set of automobile distributor points). The position of *E* is adjusted by rotation about the mounting screw. The contact of *C* with *E* closes the coil circuit of *F*, a single-pole single-throw, normally open 115-volt a.-c. relay (MR3A Potter and Brumfield). This relay controls the 115-volt a.-c. circuit energizing electromagnet *H* which consists of a Potter and Brumfield MS2A relay rewound with No. 28 enameled copper wire. An electric light bulb, *J*, (50–150 watts) is placed in series with this circuit to limit the current, drawn by the electromagnet. When the electromagnet is energized, assembly *I* is withdrawn from pin *J*, allowing the turntable to turn. Since the "blurp" from the siphon displaces bar *C* from its resting position for only a fraction of a second, the electromagnet is energized for an adequately short period and allows the moving assembly to spring back to engage the next pin on the receiver rack. The receiver rack is made from pressed fiber board with the pins set in the periphery of the bottom section spaced to correspond to the receivers. When small receivers are used a funnel is placed between *B* and the receiver.

When the liquid to be fractionated is conducting and noninflammable, two platinum wires, arranged so that the "blurp" completes the circuit of the relay, may be used to replace the mechanical switch shown.



An Automatic Constant-Volume Fraction Collector

Although this particular apparatus has been described in some detail, we wish to emphasize that most of these details are not critical. The bend in the delivery arm of the intermittent siphon is of course necessary. It is also important that the electromagnet be energized for a period sufficiently long to allow *I* to be withdrawn. The brushing contact of bar *C* with *E* makes possible the fulfillment of this requirement. The details of the receiver rack, the turntable, and the electrical circuit are all subject to the individuals' needs and ingenuity.

[1] Work supported in part by a contract between the Charles F. Kettering Foundation and The Ohio State University Research Foundation.

LITERATURE CITED

(1) STEIN, W. H., AND S. J. MOORE, *Biol. Chem.*, **176**, 337 (1948).
(2) HOUGH, L., J. K. N. JONES, AND W. H. WADMAN, *J. Chem. Soc.* **1949**, 2511.
(3) PHILLIPS, D. M. P., *Nature*, **164**, 545 (1949).
(4) RANDALL, S. S., AND A. J. P. MARTIN, *Biochem. J.*, **44**, Proc. ii, (1949).
(5) GILSON, A. R., *Chemistry & Industry*, **1951**, 185.
(6) GRANT, R. A., AND S. R. STITCH, *ibid.*, **1951**, 230.
(7) HARRIS, J. O., *ibid.*, **1951**, 255.
(8) EDELMAN, J., AND R. V. MARTIN, *Biochem. J.*, **50**, Proc. xxi, (1952).

A PERIODIC TABLE FOR THE LECTURE ROOM

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METHODS of making visual the periodic character of a number of the properties of the elements are most important to teachers of general and inorganic chemistry.

A number of recent papers deal with such representations.[1-5]

Attractive as these suggestions are, some are not applicable to use in a lecture room and those which are show only one or two properties. It is possible to correlate much chemistry with atomic and ionic sizes, but certainly it would be helpful for the students, at least occasionally, to be able to see periodic relations of other properties.

The recent completion of a large (14 ft. 9 in. × 6 ft.) periodic table (Figure 1) in our lecture room and our previous efforts[6] at representing properties on a small scale have led us to investigate a plan more versatile than others for showing periodic properties to a large class. Our plan is to assign to each element for each property to be studied a square cardboard block marked off, at least in theory, into 100 smaller squares. The magnitude of the numerical value of the property for the element is represented by an appropriate number of the small squares with usually some fraction of an additional square. One counts off the squares from the lower left, moving from left to right along a horizontal row. After the completion of one row, the next higher one is begun at the left. For example, for the melting points shown in Figure 2, the 100 small squares represent 3850°K. For lithium, melting point 452°K., a total of $11\frac{3}{4}$ small squares, 10 in the bottom row and a small section of the left side of the next row, are required. When this method is used for small-sized tables,[6] the proper number of squares is darkened. For our lecture room use the proper area was laid out on a card six inches wide and a maximum of six inches high (not counting the inch flap at the bottom for mounting), and the card was then cut to include only this area.

Wood strips with 1 in. × 1 in. cross section and as long as the different periods required were obtained and painted dull black. Four stranded wires were hung from hooks above the lecture-room periodic table, and the wood strips were attached to the wires at the appropriate horizontal levels for the different periods. The strips were bored for the wires, or the wires were stapled to the ends of the strips as each location required. A comparison of Figure 1 with Figure 2 shows the location of the strips. This framework was then used for mounting the previously described property cards, one for each element.

Our periodic-table block for each element is 7 in. × 9 in. The property card, 6-in. wide and at most 6-in. high, is attached to the wood strip to cover a portion of the symbol of the element, but the atomic number is left exposed for ready identification of the element from a textbook periodic table or list of elements. We use yellow cards to contrast best with our white table and its black, green, and orange symbols, black atomic weights, and red atomic numbers. The flap on each card for the thumb-tack attachment is covered with black picture-binding tape, and black-headed thumb tacks are used. The fastening can thus be done on the front side of the wood strips without leaving any disturbing evidences of the attachment.

Both horizontal and vertical relationships among the elements for the property displayed are obvious to the entire class at the same time. This method makes apparent variations in the magnitude of properties in a

[1] CAMPBELL, J. A., J. CHEM. EDUC., **23**, 525 (1946).
[2] CAMPBELL, J. A., *ibid.*, **25**, 558 (1948).
[3] GARRETT, A. B., *ibid.*, **25**, 544 (1948).
[4] KELLER, R. N., *ibid.*, **28**, 312 (1951).
[5] KLINGENBERG, J., AND L. SPRINGMAN, *ibid.*, **29**, 81 (1952).
[6] HAZLEHURST, T. H., AND F. J. FORNOFF, *ibid.*, **20**, 77 (1942).

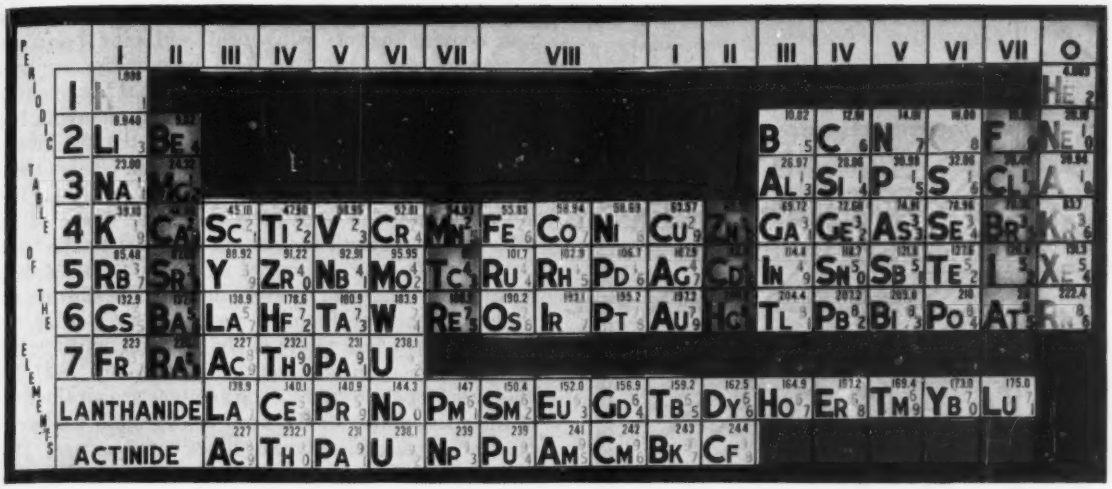

Figure 1. The periodic table of lecture room size shown with the lights on and without the frame used in showing the periodic relations.

small space even when the variations are rather small. Notice, for example, that the irregularities in the melting points of the alkaline earth metals are readily apparent. The photograph for the figure was retouched to show the outlines of the cards since the yellow-white color contrast is not recorded by photographic film.

Any large periodic table may be used for this sort of property display. Our table has the feature of separately controlled lights for each of the elements. We can thus illuminate the block for the element in each period with the highest or the lowest value of the property and so make quite striking the regularity—or the shifts—in the locations of these extremes from one period to the next.

With some planning and some preparation for the thumb-tack attachments, one can shift from one set of property cards to another in fairly short order, but one would rarely want to take class time for this. We have not found that being forced to take up only one property

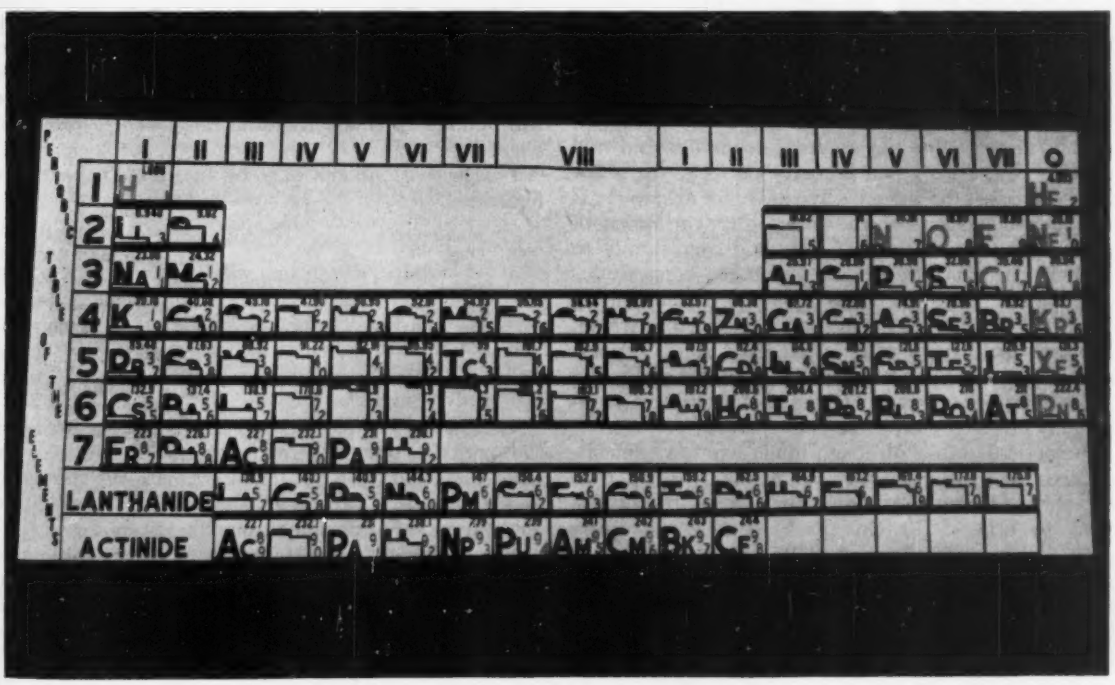

Figure 2. Periodic representation of the melting points of the elements. The magnitude of the area of the card in front of the symbol is a measure of the melting point of the element.

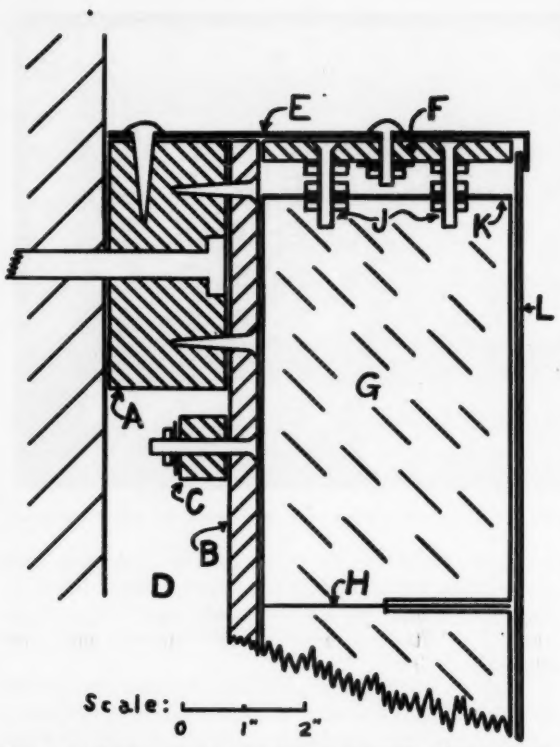

Figure 3. Diagram showing constructional details of the periodic table. A, wood frame of 2 in. × 4 in. boards; B, fiberboard backing to which light sockets were attached; C, reinforcing wood frame around fiberboard; D, space for wiring; E, heavy metal outer frame of angle iron; F, wood inner frame to which sheet metal uprights, G, and the sheet metal horizontals, H, are attached; J, tension adjusting bolts; K, right-angled flap of sheet metal for this attachment; L, white opal glass face.

in a period, along with the other material for the remainder of the class time, is necessarily bad. Too many periodic properties in one day make a difficult body of material for the students to understand and master. Considering one property per class for a few days encourages discussion. We have, for example, explored explanations for the interesting variations of melting points within each family and from family to family. The elements with no cards can be easily located, and the class can develop periodic understanding by making predictions for missing values. The frame, after the cards have been removed, may be left in place over the periodic table, or it may be removed and rolled up for compact storage. The cards for any one property may be easily stored in a large manila envelope.

Our periodic table, although much like the one constructed by F. B. Dutton[7] at Michigan State College, has several variations that may be of interest to others: (1) Our back piece is of fiberboard rather than plywood. The fiberboard comes in sheets almost large enough for a table of our size without seams. We have covered the back with two coats of aluminum paint rather than with sheet aluminum. (2) The network of metal boxes, one for each element, was constructed of 18 vertical and nine horizontal strips, appropriately slotted to permit the egg-crate type of interlocking. In order that the strips might be drawn tight, the method of attachment shown in Figure 3 was used. Other constructional details are also shown in this figure. The entire network is mounted in a wood frame which is set into and attached to the iron angle-pieces which constitute the outer frame of the table. The network is thus not fastened to the backboard and so can be removed as a unit if this becomes necessary. Although measurement for the slotting was carefully done, we found it necessary to glue narrow strips of paper into many of the box corners to reduce light leakage from one box to its neighbors. (3) The glass used is white opal. The symbols are on the front of the glass, and with the white background we have a most effective table whether illuminated or not. The lights were off for Figure 2 and were on for Figure 1. The light transmitted is somewhat reduced by this choice of glass, but glass wool was not used in front of the bulbs, and we still have very good light diffusion as shown in Figure 1. (4) The use of transparencies[8] and of decals[8] for atomic numbers and weights obviated the need for a painter. An adhesive-backed cloth tape was used for the lines. We found it possible to get a variety of colors in transparencies of the right sizes, and so we employed different colors for the symbols to show which elements are in each of the three states of matter at room temperature. Each letter, number, and period is a separately applied unit. (5) To suggest the chemical relationships as fully as possible the symbols for thorium, protactinium, and uranium, as well as those of lanthanum and actinium, appear twice on the table. For each of these elements one switch controls both lights, but the colors of the bulbs are those required for the families in which the dual relationships place the elements.

Prospective builders may be interested in our cost figures:

Metal pieces	$ 36.50
Glass	60.06
Electrical supplies	141.62
Paint	26.04
Lumber	25.14
Decals, transparencies	51.00
Hardware (bolts, screws, etc.)	34.60
Miscellaneous	25.04
	$400.00

These costs include the framework and the cards for the periodic property representations. We had no labor costs and have not dared estimate the time used on the project. Talking to another builder would no doubt have saved us much time.

The usefulness and attractiveness of the table as a teaching aid in presenting the periodic and other properties of the elements have led us to feel that our investment of time and money was worth while.

[7] DUTTON, F. B., *ibid.*, **28**, 110 (1951).

[8] Addresses of manufacturers will be furnished on request.

THE READING DIFFICULTY OF TEXTBOOKS FOR HIGH-SCHOOL CHEMISTRY

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DURING the last half century one of the major concerns of professors of chemistry and physics in teachers colleges, and of teachers of chemistry and physics in high schools, has been the steady decrease in enrollments in high-school chemistry and physics. While it is true that the decrease in enrollments is not especially noticeable in number, it is noticeable in the drop in percentage enrollment that has taken place. These facts are evident in reports by the U. S. Office of Education.[1, 2, 3]

Further, the Central Association for Science and Mathematics Teachers has established the Committee on the Significance of Mathematics and Science in Education to investigate the reasons for decrease in enrollments in these courses.

Of course, a number of reasons are obvious for such a drop in enrollments. Whereas the high school was designed formerly for students intending to go to college, it has become a training ground for all citizens, many of whom are entering occupations in which chemistry and physics have little or no significance. Also, the general intellectual level of the high school is more and more closely approximating that of the level of the over-all population. Thus, many of the areas and topics found in chemistry and physics, as well as many of the published materials for use in these subjects, may be too difficult for the average of the present high-school population. As a result, there may be an effort on the part of students to avoid these subjects.

With respect to the point about the difficulty of published materials, a number of studies have been undertaken recently concerning the levels of reading difficulty of textbooks for science.[4–10]

In essence, all these studies indicate the following:

1. The reading levels of many textbooks in science are too advanced for students for whom they are written.

2. The differences between the levels of reading difficulty of the easiest and the most difficult textbooks in any area of science are significant.

3. In some textbooks of science whose *average* level of reading difficulty seems satisfactory, there are passages that would be difficult even for some college students.

4. Many textbooks of science contain nontechnical words that could be replaced with easier synonyms.

However, none of these conclusions applied specifically to textbooks in the field of chemistry. Hence it was decided to extend these studies to textbooks for high-school chemistry to determine if the same conditions obtained in that area. This investigation therefore deals with textbooks of high-school chemistry.

A search was made to locate the titles of textbooks designed for use in chemistry. The search revealed

[1] "Offerings and Enrollments in High-School Subjects," 1948–49, *Biennial Survey of Education in the United States* 1948–50, Chapter 5. Office of Education, Federal Security Agency, Washington, D. C.

[2] "The Program of Studies," Bulletin No. 17, 1932. Monograph No. 19. Office of Education, United States Department of Interior, Washington, D. C., 1933.

[3] "The Teaching of Science in Public High Schools," Bulletin No. 9, 1950. Office of Education, Federal Security Agency, Washington, D. C., 1950.

[4] MALLINSON, G. G., "Some problems of vocabulary and reading difficulty in teaching junior high school science," *School Sci. and Math.*, **52**, 269–74.

[5] MALLINSON, G. G., "The readability of high school science texts," *The Sci. Teacher*, **18**, 253–6.

[6] MALLINSON, G. G., H. E. STURM, AND L. M. MALLINSON, "The reading difficulty of textbooks for general science," *School Review*, **52**, 94–98.

[7] MALLINSON, G. G., H. E. STURM, AND R.E. PATTON, "The reading difficulty of textbooks in elementary science," *Elementary School J.*, **50**, 460–63.

[8] MALLINSON, G. G., H. E. STURM, AND L. M. MALLINSON, "The reading difficulty of textbooks in high-school biology," *Am. Biol. Teacher*, **12**, 151–56.

[9] MALLINSON, G. G., H. E. STURM, AND L. M. MALLINSON, "The reading difficulty of textbooks in junior high school science," *School Review*, **50**, 536–40.

[10] MALLINSON, G. G., H. E. STURM, AND L. M. MALLINSON, "The reading difficulty of textbooks in high school physics," *Sci. Educ.*, **36**, 19–23.

twenty-two such textbooks, all of which were used in this investigation. Since analysis of all the textual material in all the textbooks was impractical, a modification of the sampling technique suggested by Flesch[11] for use with his formula was employed.

It was decided to select from each textbook one sample passage for each one hundred pages or fraction thereof, but not less than five passages from any one textbook.

The number of pages in each textbook was computed by counting from the first page designated by an Arabic numeral to the last page of the last chapter. Pages upon which were found chapter endings, supplementary activities, and questions were included in the count. Pages upon which were found indexes, glossaries, and tables of contents were excluded.

The number of pages in each textbook was then divided by the number of samples to be taken from the book. In this way each textbook was divided into sections of an equal number of pages. A page was then selected from each of the sections by using a table of random numbers.

A one-hundred-word sample was taken from each page thus selected by counting from the first word of the first new paragraph on that page. If the page contained no reading material, the sample was selected from the next page that did. Legends under illustrations on these pages were disregarded. These samples were then analyzed by use of the Flesch formula.

The Flesch formula takes cognizance of the number of words in the sentences found in the sample passages, the number of personal references (*we, they*, etc.) in the passages, and the number of affixes and suffixes (syllabification) to the words. These various aspects of sentence structure are measured in each of the one-hundred-word samples and are translated into a reading-difficulty score by means of the formula. The reading-difficulty score is converted, in turn, into a grade-level value of reading difficulty. The conversion is made by using Table 1.

TABLE 1
Grade Levels of Difficulty Equivalent to Reading-Difficulty Scores[a]

Reading-difficulty score	*Description of style*	*Grade level of difficulty*
0–1	Very easy	Grade IV completed
1–2	Easy	Grade V completed
2–3	Fairly easy	Grade VI completed
3–4	Standard	Grade VII or VIII
4–5	Fairly difficult	Two years of high school
5–6	Difficult	High school and some college
6 and up	Very difficult	College completed

[a] Flesch, Rudolf, *op. cit.*, p. 205.

Table 2 lists the following information for the textbooks designed for chemistry: (1) the textbook publishers (designated by the letters A, B, C, etc.); (2) the reading-difficulty scores of the samples taken from the textbooks; (3) the average reading-difficulty score for each textbook; and (4) the grade level of difficulty for each textbook.

A survey of the data in Table 2 indicates that the levels of reading difficulty of the textbooks for chemistry vary greatly. But there is no evidence in these tables to indicate that the differences between the levels of difficulty of the easiest and the most difficult textbooks are significant. Hence, it was decided to compute the significances of the differences between the levels of reading difficulty of the easiest and the most difficult textbooks.

The textbooks were classified into four groups according to ascending order of difficulty. The first group consists of the five "easiest" books; the second group, of the next six with respect to difficulty; the third group, the next six; and the fourth group, of the five most difficult. Significances of differences were then computed between various groups. The statistical device employed was Fisher's t cited by Guilford.[12] Table 3 lists the significances of the differences computed in the manner just stated.

Any conclusions listed herein must be evaluated in the light of several factors. Among them are the following:

1. Many students are *below* average in reading ability. Hence, for any particular grade level, the reading difficulty of the textbooks should be below that of the grade in order to be suitable for these students.

2. The course in chemistry is designed usually for students at the XI or XII grade levels.

In view of these factors and in so far as the techniques used in this study may be valid, the following conclusions seem defensible:

1. The data in Table 2 indicate clearly that the levels of reading difficulty of the passages within the separate textbooks vary greatly. The easiest passage in the textbook of Publisher R has a grade level of difficulty of Grade VII; the most difficult passage, of college level. The easiest passage in the textbook of Publisher T has a grade level of difficulty of Grade VII; the most difficult, of college completed. If these two are representative of the variation of levels within a textbook, it is clear that in any textbook some passages are not likely to cause difficulty for any of the students for whom they are designed, but that other passages are likely to cause difficulty for all students for whom they are designed.

It is therefore clear that the average reading-difficulty score for a textbook may be somewhat misleading. Some textbooks that have many extremely difficult passages may be balanced by some very easy ones.

2. The grade levels of difficulty of textbooks in chemistry vary greatly. The easiest textbook has an average level of reading difficulty of Grade VIII. It is

[11] Flesch, Rudolf, "The Art of Plain Talk," Harper and Bros., New York, 1946, p. 197.

[12] Guilford, Joy P., "Psychometric Methods," McGraw-Hill Book Co., Inc., New York, 1936, p. 61–62.

TABLE 2
Levels of Reading Difficulty of Textbooks for High-School Chemistry

Publisher	Reading-difficulty score for sample 1	2	3	4	5	6	7	8	Average reading-difficulty score[a]	Grade level of difficulty[b]
A	3.64	4.15	3.91	3.18	3.63	3.23	—	—	3.623	VIII
B	3.70	4.57	3.18	3.82	3.17	2.64	3.18	5.03	3.661	VIII
C	3.52	4.03	3.49	4.91	2.97	3.49	3.65	—	3.724	VIII completed
D	3.86	5.23	4.22	3.44	3.69	2.23	3.69	—	3.766	VIII completed
E	3.19	3.76	3.11	3.84	4.62	4.45	—	—	3.828	VIII completed
F	2.92	4.74	4.36	4.33	5.02	4.09	3.76	—	3.888	VIII completed
G	3.98	3.71	3.97	3.64	5.03	4.34	—	—	4.111	IX
H	4.76	4.65	4.23	3.45	3.57	—	—	—	4.132	IX
I	3.76	4.42	4.68	3.52	4.35	4.23	4.81	—	4.253	IX completed
J	5.41	3.65	3.63	4.92	3.57	3.97	4.80	4.16	4.264	IX completed
K	3.82	4.29	4.12	3.69	6.39	3.43	—	—	4.290	IX completed
L	4.91	3.80	3.22	5.73	3.55	3.76	—	—	4.328	IX completed
M	3.70	3.38	3.99	4.45	5.35	5.10	4.55	—	4.360	IX completed
N	4.91	3.70	3.64	4.67	5.36	—	—	—	4.456	IX completed
O	4.36	5.62	4.12	4.35	4.34	3.78	4.70	—	4.467	IX completed
P	4.78	5.36	3.71	4.77	3.79	—	—	—	4.482	IX completed
Q	5.53	5.88	5.00	4.25	3.86	3.94	3.73	—	4.584	X
R	3.19	5.11	5.62	4.77	4.31	4.57	4.62	—	4.599	X
S	4.80	5.21	5.75	4.91	4.20	3.91	3.96	—	4.677	X
T	3.76	4.25	6.31	3.23	5.23	5.62	6.06	4.19	4.831	X completed
U	3.75	4.54	4.87	5.78	5.86	—	—	—	4.960	X completed
V	4.78	5.06	5.22	5.88	5.56	—	—	—	5.300	High school completed

[a] The average reading–difficulty score for all textbooks for chemistry is 4.327, which is equivalent to a grade level of difficulty of about the sophomore level of high school.
[b] Grade levels of difficulty were computed by using data in Table 1.

unlikely that this textbook will prove difficult for many students likely to be enrolled in chemistry, that is, students in Grades XI or XII.

The most difficult textbook with an average level of reading difficulty of high school completed is likely to be difficult for all but the very superior students. In fact, the next five textbooks in difficulty are likely to be difficult for many of the students likely to be enrolled in the course.

3. As compared with textbooks of physics, textbooks of chemistry that are designed for students of the same grades vary less in range of reading difficulty. As a group, the average levels of reading difficulty of textbooks of chemistry range from Grade VIII to high school completed. Those for physics range from Grade VII to college completed.

4. As with the other textbooks of science that were analyzed, the earlier passages in chemistry textbooks do not seem to be consistently lower in level of reading difficulty than the later passages. Hence, no provision seems to be apparent for growth of reading ability during the year in which the books are used.

5. Table 3 indicates that the books tend to fall into three categories with respect to reading difficulty. The easiest quarter (five textbooks) is significantly less difficult than the middle half (twelve textbooks). The middle half is significantly less difficult than the most difficult quarter (five textbooks).

6. It seems reasonable to state from the conclusions already listed that the differences found make level of reading difficulty a valid criterion for use in the selection of a textbook.

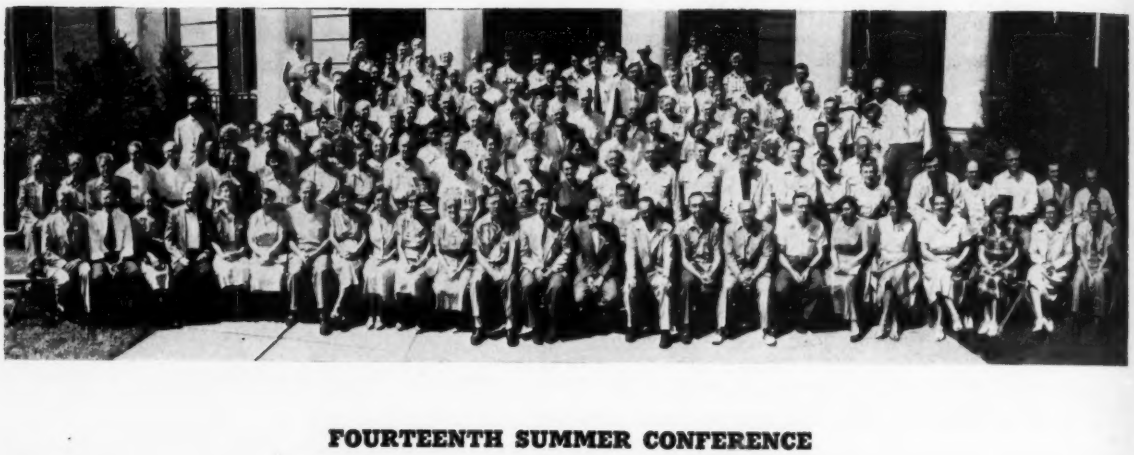
7. In view of the findings of this investigation, it may be stated that textbooks of chemistry as a group are not likely to be as difficult for the students for whom they are designed as are textbooks in other fields of science. However, those in the most difficult group are likely to cause difficulty for the less able students in chemistry. But, the most popular chemistry textbooks are found in the easiest and middle groups with respect to reading difficulty. Hence the reading difficulty of the popular textbooks in the field of chemistry is not likely to discourage students from enrolling in chemistry.

TABLE 3
Significances of Differences between Various Levels of Difficulty of Chemistry Textbooks

Groups compared	Mean difference	Standard error of difference	"t"	Probability level	Interpretation
1 and 2	0.49	0.154	3.18	$P < 0.01$	Very significant
2 and 3	0.21	0.161	1.30	$P > 0.05$	Not significant
3 and 4	0.42	0.189	2.22	$0.05 > P > 0.01$	Significant

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS



FOURTEENTH SUMMER CONFERENCE

THE 14th Summer Conference of the New England Association of Chemistry Teachers met August 18–23 at the University of Vermont at Burlington, with William F. Ehret and Marco Scheer as Co-Chairmen. The new President of the University, Carl W. Borgmann, welcomed the Conference to the campus and called the attention of the group to the fact that he is a former chemist himself. There were 275 registrants at the 14th Summer Conference, of whom about one-third were from outside of New England. Besides the New Englanders present, this year there were registrants from the States of Washington, Kentucky, Ohio, Illinois, Maryland, Pennsylvania, New York, New Jersey, and Virginia, and from Washington, D. C. and the Province of Quebec.

In addition to the papers presented by speakers from several colleges and industries, two symposia were presented. The first was an all-day session led by Dr. John H. Harley, Chief of the Analytical Branch, Health and Safety Division of the New York Operations Office of the U. S. Atomic Commission, on "The Use of Available Radioisotopes in the Teaching of General Chemistry." A number of demonstrations were given, which will be presented in detail in the NEACT *Newsletter*.

The second symposium entitled "The Evaluation of Laboratory Work in General Chemistry" was conducted by Professors Arnold J. Currier, Pennsylvania State College, Andrew J. Scarlett, Dartmouth College, and Carl P. Swinnerton, Pomfret School.

Leonard Foley of the Manchester Central High School, Manchester, New Hampshire, headed the Exhibit Committee. New books from several publishing houses and apparatus from various dealers and makers of glassware made up a colorful and useful exhibit. Ralph DiMattia, Grover Cleveland School, Dorchester, Massachusetts, again had charge of the motion pictures which were shown just before the evening sessions.

The social hours that followed the evening meetings were held in the Fleming Museum of the University of Vermont. One of the highlights of the social hours was a military whist which made it easy for people to become acquainted with each other. The Wednesday picnic was an elegant chicken barbecue, held at the Poultry Division of the University in sight of large, lively flocks of still unbarbecued brothers and sisters.

ADJOURNED ANNUAL MEETING, AUGUST 22, 1952

The adjourned annual meeting of the NEACT was convened at 11:30 A.M. by the President, Dorothy W. Gifford.

The Treasurer's report was presented. An abridged statement follows:

Expenses for the year	$2021.40	
Receipts	1959.43	
Deficit	$ 61.97	
Balance July 1, 1951		$1447.21
New balance June 30, 1952		1385.24
		61.97

Leallyn B. Clapp, Secretary, reported that three new members had joined after the May meeting:

Samuel E. Q. Ashley, T A P Lab., General Electric Co., 100 Woodlawn Avenue, Pittsfield, Massachusetts.
William S. Coley, 66 Washington Terrace, Bridgeport, Connecticut.
Leigh C. Van Etten, Kents Hill School, Kents Hill, Maine.

At the 14th Summer Conference the following new members were welcomed into the Association:

Arnold I. Beck, Adelphi College, Garden City, New York.
James S. Bennett, 11 Bonair Avenue, Newington, Connecticut (Chairman, Chemistry Department, Hillyer College, Hartford).
Anne T. Caswell, Milwaukee-Downer College, Milwaukee 11, Wisconsin.
Ralph E. Cullmann, 225 North First Street, Bellingham, Washington (Assistant Professor of Physical Science, Western Washington College of Education).
Paul R. Doe, 12 Kendall Street, Rochester, New Hampshire (Spaulding High School).
T. M. Gorski, Alliance College, Cambridge Springs, Pennsylvania.
Roy I. Grady, 1753 Burbank Road, Wooster, Ohio.
G. G. Hawley, Reinhold Publishing Company, 330 West 42nd Street, New York 36, New York.
Durward Holman, Ocean House Road, Cape Elizabeth, Maine (Cape Elizabeth High School).
Joseph H. Klein, Box 286 R T I, Gambrills, Maryland (Assistant Professor, U. S. Naval Academy, Annapolis).
Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wisconsin.
Ruth Lindquist, Lasell Junior College, Auburndale, Massachusetts.
Daniel P. Nolan, 805 Fairmont Street, Latrobe, Pennsylvania (Head of Chemistry Department, St. Vincent College, Latrobe).
Peter Richardson, Pomfret School, Pomfret, Connecticut.
Orville W. Rallins, Box 210, Arnold, Maryland (Assistant Professor of Chemistry, U. S. Naval Academy, Annapolis).
Stephen George Romaine, 102 Tredeau Street, Hartford 14, Connecticut (Ellsworth Memorial High School, South Windsor, Connecticut).
Richard L. Saville, Box 6, Interlaken, Massachusetts (Williams High School, Stockbridge).
John J. Sheehan, Jr., 18 Catalpa Road, Norwood, Massachusetts.
Moddie D. Taylor, Howard University, Washington, D. C.
Harry Wessels, 55 Winthrop Street, New Britain, Connecticut (Principal, Nathan Hale High School).
Mary L. Willard, 363 Ridge Avenue, State College, Pennsylvania (Professor of Chemistry, Pennsylvania State College).
Roberta Whitnah, Murray State College, Murray, Kentucky.
Louise Willis, Pittsford, Vermont (Head of Science Department, Pittsford High School).

The Secretary reported the membership on July 1st at 521. Total for the year 535, with 12 resignations and 2 deaths. Twenty-one new members joined at the 14th Conference, raising the total to 542.

President Gifford presented an engrossed certificate of Honorary Membership to Eva M. Ruggli.

S. Walter Hoyt reported on the deaths of Arthur B. Lamb and Leslie O. Johnson, and presented the obituaries printed at the end of this *Report*.

President Gifford announced that the University of Massachusetts, Amherst, Massachusetts, had invited the NEACT to hold the 15th Summer Conference there next August, subject to final confirmation in September. John Cavelti, Allegheny College, and Guy Burrill, Keene (New Hampshire) High School, are to be Co-Chairmen for the Conference.

President Gifford announced that she planned to appoint three subcommittees of the Chemical Education Committee, for the purpose of undertaking the following studies:

1. Criteria for judging science fairs
2. Chemistry syllabus to serve as a guide for prospective nursing school students
3. Revision of the chemistry syllabus for College Board Examinations

Alfred Lincoln presented a resolution which was unanimously adopted, recognizing the vision of the founder of the Summer Conferences, namely, Elbert C. Weaver. It was appropriate at this time inasmuch as the first summer conference, in 1939, was also held at the University of Vermont.

The following members have attended all 14 summer conferences:

Mr. and Mrs. Grover C. Greenwood, Bridgeport, Connecticut.
Mr. and Mrs. S. Walter Hoyt, Belmont, Massachusetts.
Alfred R. Lincoln, Springfield, Massachusetts.
Evelyn S. Murdock, Stonington, Connecticut.
Elsie S. Scott, East Northfield, Massachusetts.
John R. Suydam, Boston, Massachusetts.
Elbert C. Weaver, Andover, Massachusetts.

A vote of thanks was authorized to the University of Vermont for the use of its facilities at the Conference, and a vote of appreciation to the Conference Committee for making the 14th Summer Conference possible.

NEACT MEETINGS SCHEDULED, 1952–53

The following meetings were announced by the Executive Committee:

October 18, 1952, St. Paul's School, Concord, New Hampshire.
(Joint meeting with Eastern Association of Physics Teachers)
December 13, 1952, Boston College, Chestnut Hill, Massachusetts.
(Joint meeting with Eastern Association of Physics Teachers and New England Biological Association, held in conjunction with the New England Association of Secondary Schools and Colleges)
February 14, 1953, Mary C. Wheeler School, Providence, Rhode Island.
April 12, 1953, Teachers College of Connecticut, New Britain, Connecticut.
May 9, 1953, Regis College, Weston, Massachusetts. (Annual Meeting)
15th Summer Conference, August 17–21, 1953, University of Massachusetts, Amherst, Massachusetts.

NECROLOGY

ARTHUR BECKET LAMB. The necrology committee regrets to report the death on May 15, 1952, of Arthur Becket Lamb, Erving Professor of Chemistry, *Emeritus*, at Harvard University. Dr. Lamb died suddenly on his way home from his laboratory. Dr. Lamb's Brookline, Massachusetts, residence was at 121 Colburne Cresent.

Dr. Lamb had been a member of the New England Association

of Chemistry Teachers since 1913, except for the period 1918–21, and on August 25, 1950, was elected an Honorary Member. On receipt of his honorary membership certificate Dr. Lamb wrote to President Helen Crawley as follows: "I want to express my appreciation of the splendid certificate of honorary membership that you recently sent me. It is beautifully executed and bound and will always be one of my treasured possessions."

The following is a brief summary of his career.

He was born in Attleboro, Massachusetts, on February 25, 1880, and was graduated from the local high school, entering Tufts College from which he was graduated in 1900 with the degree of A.B. and A.M. In 1904 he took his Ph.D. degree and, was awarded his D.Sci. (hon.) by Tufts College in 1922.

His teaching career, is as follows:

Instructor of Chemistry, Tufts College, 1901–02.
Instructor of Physical Chemistry, Harvard University, 1905–06.
Assistant Professor, Associate Professor, and Professor of Chemistry, New York University, 1907–12.
Assistant Professor and Professor of Chemistry, Harvard University, 1912–20 and 1920–48.
Dean of the Graduate School, Arts and Sciences, Harvard University, 1940–43.

His war record is as follows:

Director: Fixed Nitrogen Laboratory, Washington, 1919–21.
Lieut. Colonel: Research Division, Chemical Warfare Service, Washington, 1918–19.
In charge of Defense Chemical Research during World War I.

For 32 years, beginning with 1917, he was Editor of the *Journal of the American Chemical Society* and served as President of the American Chemical Society in 1933. He was the recipient of the Nichols Metal in 1943, the Ballon Metal of Tufts College in 1944, and the Priestley Medal in 1949.

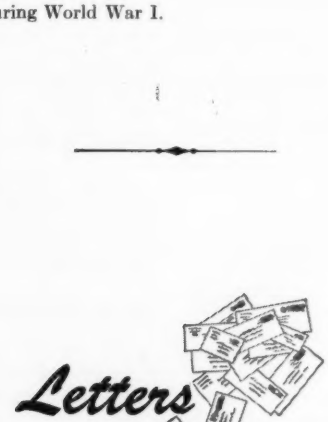
LESLIE O. JOHNSON. The necrology committee regrets to report the death on July 22, 1952, of Leslie O. Johnson. While on a motor trip to Canada with his wife, Mr. Johnson was stricken with a fatal heart attack at Jackman, Maine.

A former president of the New England Association of Chemistry Teachers, Leslie O. Johnson recruited and organized its Western Division during the Reconstruction Drive of 1921, and became the first chairman of this division.

After graduation from Amherst College in 1915 he taught science in Waterloo, New York; Brattleboro, Vermont; Wellesley, Massachusetts; Malden, Massachusetts; and New Haven, Connecticut. In 1925, he became principal of the Rutland, Vermont, High School and in 1931, came to Gloucester, Massachusetts, as principal of the High School where he served until 1951. Last year he was made superintendent of the Gloucester schools.

He leaves his wife, the former Ethel K. Fowler of Malden, one daughter, Elspeth Burnett (Mrs. William A. Publicover, Jr.), his mother, Mrs. George Johnson of Melrose, and one sister. His uncle, William W. Obear, is a past-president of the New England Association of Chemistry Teachers.

S. WALTER HOYT
President, Necrology Committee



To the Editor:

A colleague of mine, meeting up with a practical problem, consulted me for a solution. I found the problem not altogether as simple as it appears. Further, it comes more immediately within the chemist's domain, so I consulted a couple of chemists. They were sensibly hard-put! With these experiences it occurred to me that your readers might have an interest in it.

A certain brand of baby-oil comes in large 12-oz. bottles and small 4-oz. bottles. The larger is more economical but the smaller bottle is easier to handle. Both bottles are equipped with *small* orifices in the neck of the bottle so that the oil comes out *in drops* by shaking the bottle as one would do, say, with hair-tonic. The oil will not run freely however the bottle is held, nor will it come out even in drops unless the bottle is shaken. If, now, we have a large bottle full of oil and a small one empty, how can the oil be *readily* transferred from the large bottle to the small one? The problem is to produce steady flow with no losses.

JULIUS SUMNER MILLER

UNIVERSITY OF CALIFORNIA
LOS ANGELES, CALIFORNIA

Film Reviews

• LIQUIDS

Description: 16 mm., sound, 10 min.

Producer: American Film Registry

Reviewers: (A) I. H. Shroyer, Bradley University
(B) John L. Biester, Beloit College

Possible Utility: (A) "My recommendation would be that this film is definitely worth while for superior high-school students and first year college groups. It certainly should not be offered to seniors studying physical chemistry." (B) "This film could be used as a point of departure in discussions of liquids particularly in high-school physics classes. It might be of help in college courses designed for the general student who may be quite unfamiliar with the phenomena illustrated. However, I would not recommend the film for most college chemistry courses."

Film Content: (A) "Treats qualitatively the following topics: surface films, viscosity of liquids, adhesion and cohesion in liquids. These topics are given a short animated presentation followed by actual photographed demonstrations, some of which are very good and not usually mentioned in college general chemistry texts. There is an extensive group on bubbles and liquid jet behavior." (B) "...using water as the example. The principles underlying the phenomena illustrated are not considered."

General Criticism and Rating: (A) "The film has merit and meets the test of general accuracy. It gives the impression of having added something new to the student's knowledge; for example, that two jets do not fuse until brought into contact by the static charge carried by a stick of sealing wax. This fact, however, was not sufficiently developed in my estimation." (B) "It should be pointed out that at least on the print reviewed, many of the scenes were difficult to follow because photography appeared to be poor. This might also be due to extensive cutting of the film over a period of use."

Suggestions for Improvement: (A) "Realizing that I am expressing just one opinion, may I suggest:

"(1) Abolition of opening a film with beautiful scenery shots which always suggests to the student, 'Now relax while we entertain you.'

"(2) Introduction of a quantitative aspect such as an equation or two, perhaps the one for viscosity, and detailing something of its terms and its overall significance.

"(3) In general, I find that most films tend to treat the subject less rigorously than we do in class work. Should not the film endeavor to elucidate some of the more obscure but important aspects of the subject that give the student some difficulty?"

• NEW WORLD THROUGH CHEMISTRY

Description: 16 mm., sound-color, 20 min.

Producer: du Pont Co.

Reviewers: (A) C. W. Keenan, University of Tennessee
(B) M. D. Peterson, Vanderbilt University

Possible Utility: (A) "The chemistry involved...is so deemphasized that the film is poorly suited for any specific chemistry course, even a survey-type course." (B) "...it is of no value to teachers of chemistry at any level."

(A) "The film could be suitable for a course in customer relations, general salesmanship, or for giving a very glossy picture of what chemistry and engineering can do to change crude raw materials into more useful products." (B) "It is solely advertising, aimed at nontechnical audiences."

Film Content: (A) "This film gives a salesman's view of the manufacture and use of modern plastics from the raw materials to the finished products. Color scenes of mining, machinery, and spinning precede scenes showing various products of modern du Pont polymers and their uses." (B) "The film shows very brief flashes in plant and laboratory of manufacturing and testing steps for a few products, without any adequate explanation of what is being shown, followed by long demonstrations by lovely models of neoprene, lucite, rayon, and nylon articles, in rooms of 'Hollywood' splendor."

General Criticism and Rating: (A) "The film is described in semitechnical terms, little attempt being made to distinguish chemically between neoprene, chloroprene, and kerosene or zelan, viscose, cellulose, nylon, and lucite. Even in telling about the uses of the plastic products the film avoids anything technical.... The film is not inaccurate, but it is not very informative. There did seem to be a lapse in continuity at one point where neoprene and cellulose-derived products were shown together subsequent to a description of the manufacture of neoprene."

Suggestions for Improvement: (A) "...the film would have to be completely redone and oriented toward the chemistry of polymers to be of real value. Many of the shots of polymerizations, extrusions, and combustions could be used and interspersed with diagrams clarifying the chemical reactions which take place."

• FIRST YEAR COLLEGE CHEMISTRY

John W. Barker, Professor of Chemistry, Wittenberg College, and *Paul K. Glasoe,* Professor of Chemistry, Carthage College. McGraw-Hill Book Co., Inc., New York, 1951. x + 501 pp. Illustrated. 16 × 23.5 cm. $5.

THIS is a new book of many virtues and some weaknesses. It is written primarily for the student who will take additional chemistry, rather than for the terminal student. "This text is designed to provide the foundation of encyclopedic fact and underlying principles upon which a student can predicate further work in chemistry or allied fields." (Quoted from jacket.) It is designed for a full year course, and closes with 20 pages of organic chemistry and a short final chapter entitled: So You Want to be a Chemist? In general the approach, selection and arrangement of material are quite traditional. It has been boiled down to 481 pages of text, not so much through elimination of topics as through general contraction of the usual topics.

Repetition is skillfully used to clinch concepts introduced earlier, and only occasionally (*cf.* Haber process, pages 236-7, 287-8) does the repetition become too obvious.

The apparent aim of keeping discussions on a simple plane in

the earlier chapters sometimes results in categorical statements where more reasoning would be helpful. For example, on page 19 the physical properties of covalent compounds and electrovalent compounds are contrasted, but reasons for the differences are not discussed. The attempt to be straightforward and to preserve simplicity backfires in an occasional instance. Thus, on page 74 directions are given for balancing oxidation-reduction equations. The third rule states: "If the net charges on the two sides of the equation are not equal after the equalization of total oxidation and total reduction, they are equalized by adding either H_3O^+ or OH^-, as needed, to the left side of the equation." (But later equations sometimes need the H_3O^+ or OH^- on the south side instead of on the north side.)

The Brönsted definition of acids and bases is the only one given. Hydrogen ion is consistently written as H_3O^+, but with few exceptions it is the only cation written in hydrated form, and the associated nature of water is barely mentioned.

Atomic structure is introduced early, but (as in many texts) is not made the powerful tool it could be. Some use is made of atomic radii, but the concept of kernel charge is never mentioned. The screening effect of electrons in underlying shells is ignored. Page 21, for example, states: "In the small lithium atom the electron is relatively strongly held by the nucleus, although the nuclear charge is only 3+. On the other hand, the cesium atom has a nuclear change of 55+, but the greater distance between the nucleus and the valence electron overbalances the charge effect, and the single electron is more readily lost; *i. e.*, cesium is more reactive."

This text makes consistent use of ionic equations for ionic reactions. It frequently uses half-reactions. Oxidation-reduction equations are sometimes balanced through a half-reaction and electron transfer approach, but more commonly they are balanced (without the mention of electrons) by the "oxidation-number-change" method.

The book contains many excellent problems. Many are in context in the body of the chapter, usually with answers provided. Additional exercises, usually without answers, are placed at the ends of most chapters.

Illustrative calculations commonly use ratio and proportion. Gas-law calculations are usually demonstrated by multiplying an original quantity by ratios of temperatures, pressures, etc.

In an attempt to adapt the text to various types of students, most of the chapters are divided into two sections. "In the first part, the continuum of concepts is developed. In the second part of the chapter are addenda, indexed in the first part of the chapter, which give historical background, additional factual information or advanced topics of related and special interest." (Quoted from jacket.) In the opinion of the reviewer, this plan proves disadvantageous here. The continual thumbing back and forth is inconvenient, time consuming and irritating. The addenda are printed in small type, and if they were thus inserted in the appropriate places in the body of the chapter, they could still be omitted by some students. This arrangement would take no more space, and would avoid inconveniencing those students who study the entire chapter.

The book is well indexed, and is practically free from typographical errors, but it has its full quota of errors of fact and interpretation. (Examples: Page 239 states: "Among the common metals, Zn^{++}, Cd^{++}, Fe^{++}, . . . form ammonia complex ions." *Molecules* of NaCl, Na_2O (page 15), $Na_2S_2O_3$ (page 162), calcium carbonate and calcium oxide (page 165) are spoken of. Page 11 says: "The distance separating the two bodies (of which a hydrogen atom is composed) is so great relative to their sizes that the electron does not fall in to the proton and neutralize it." In discussing the cyclotron, page 444 states: "The magnet forces the proton away from the center." Page 461 says: "Recently proposals have been made to set fire to abandoned coal mines and collect the gases which would contain *a large percentage of the lighter hydrocarbons*. These could then be used in gasoline manufacture." (Italics ours.) Occasionally a technical term is used before it is defined.

In premeditated style, the book often uses singular verbs with plural subjects. "Three liters of a gas weighs 5.3 grams" (page 6). "To melt each gram of ice, 80 cal is required" (page 185). "How many calories is required to change 20 g of liquid water. . .?" (page 186). In such usage the book is of course in distinguished company.

WILLIAM E. MORRELL

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

• QUANTITATIVE CHEMICAL ANALYSIS

Charles W. Foulk, **Professor Emeritus of Chemistry,** ***Harvey V. Moyer,*** **Professor of Chemistry, and** ***William M. MacNevin,*** **Professor of Chemistry, Ohio State University. First edition. McGraw-Hill Book Co., Inc., New York, 1952. ix + 484 pp. 98 figs. 40 tables. 16 × 23.5 cm. $5.**

THIS excellent text will appeal not only to teachers and students of analytical chemistry but to other chemists as well. Recent progress in the teaching of quantitative analysis is appropriately reflected in this book which aims to "develop in the student an understanding of the science of chemical measurement." The lucid and thorough explanations of the basic and elemental theory of analytical chemistry deserve unstinted praise. The skill with which the subject matter is brought to the level of the undergraduate is exceptional.

The design, calibration, and care of apparatus are well covered. Many valuable points of technique are explained in a thoroughly practical manner. The actual laboratory exercises, about 48 in all, are given together after most of the theory has been discussed. The relative order, (*1*) gravimetric analysis (*2*) volumetric analysis, may easily be altered by the instructor if desired. It is very reassuring to have the authors state that "the procedures have been used by a very large number of students over many years and are known to be workable and reliable." While the principal stress is still on classical chemical methods the increased emphasis on instrumental methods seems entirely appropriate. The excellent selection of instrumental methods and careful explanation of the same may be taken as a measure of the emphasis which the authors propose on this part of the subject in an elementary course and an indication of the modern trend in this direction. The fact that applicable theory must often be sought in an earlier portion of the text presents no serious obstacle. In fact, according to Doctor Foulk this arrangement results in a pedagogical advantage.

A well-written chapter on The Chemical Balance and Its Use and one on Errors and Statistical Methods in Chemical Analysis are included. The incorporation of many well devised problems, over two hundred in all with answers, greatly increases the usefulness of the text. The valuable material in the appendices concerning Materials for Lecture Demonstrations, Derivation of the Nernst Equation, The Sign of Electrode Potentials, *etc.* along with several useful tables should not be overlooked. The paper printing and binding are of good grade and suited for practical use. The illustrations are in general excellent. Only a few misprints were noticed.

Looking in the direction of an ideal text for the chemistry major the reviewer submits the following suggestions: (*1*) Add two or three laboratory exercises involving single gravimetric determinations such as the determination of silver in an alloy, phosphorus pentoxide in a phosphate mixture, sulfur in an insoluble sulfide. (*2*) Expand the discussion of specific chemical errors, interfering substances and applications in connection with all the more important determinations. (*3*) Near the end of Chapter XII on Solutions of Acids, Bases and Salts explain the titration of a salt of a very weak acid, a salt of a very weak base, a polybasic acid such as phosphoric. Include appropriate titration curves. (*4*) Explain in greater detail the use of alternative reagents other than stannous chloride for the reduction of ferric iron prior to titration. (*5*) Discuss at greater length the standardization of permanganate on arsenic trioxide. (*6*) Include one laboratory exercise on the volumetric determination of iron by means of permanganate. (*7*) List a number of oxidizing agents that can be determined by

reaction with excess potassium iodide and titration with standard thiosulfate. (*8*) Add one chapter on the theory of physical and chemical methods of separation including organic reagents. (*9*) Discuss in some detail the general application of methods studied to the analysis of alloys, insoluble silicates and complex sulfides. (*10*) Increase the number of assignable problems to at least three hundred and thus provide more drill on (*a*) equivalents and change of equivalents in volumetric oxidation and reduction, volumetric precipitation, and volumetric complex formation; (*b*) applications of the Nernst equation to the calculation of the equilibrium constant (K) and of the residual concentrations of the reactants; (*c*) percentage error in volumetric and gravimetric analyses resulting from chemical interferences; (*d*) varied aspects of electrolytic analysis; (*e*) calculation of the chemical formula from analytical data; (*f*) purely chemical questions of a non-mathematical character.

Chemists will look forward to future editions of a text with so many valuable features by authors so well qualified.

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● INTRODUCTION TO THE SCIENCE OF CHEMISTRY

***Karol J. Mysels* and *Charles S. Copeland*, both Associate Professors of Chemistry, University of Southern California. Ginn and Co., Boston, 1952. vi + 521 pp. Line drawings. 78 tables. 17 × 24 cm. $4.75.**

JUDGING from the advertising literature mailed to professors of chemistry almost daily, one could easily conclude that there are about as many freshman-chemistry text books as there are freshman-chemistry students. In fact, if the word "student" is taken literally, some would say that the text books are in the majority. What reason, then, could there be for still another text in this field? The authors answer with candor that the approach presented in this text suits them best; they hope that you too may find their approach useful.

Their approach is certainly different. This text could properly be subtitled: "An Elementary Introduction to Physical Chemistry for Students not yet Acquainted with Calculus." The first graph appears on page 7; the seven allotropic forms of ice are discussed in Chapter 3. We find catalysts, for once properly defined, on page 169; activated complexes and chain reactions are briefly mentioned in the preceding pages. Titration curves, X-ray and electron diffraction, and other similar topics are treated more thoroughly than usual on other pages. By a liberal count, only 16 of the 58 chapters are more or less devoid of physical chemistry, and of these, 9 are devoted to organic chemistry.

Those who prefer to emphasize physical chemistry in an introductory course will be pleased with the clarity of presentation and the succinctness of the arguments used in this text. For example, after a thorough preliminary treatment, the authors present $PV/(273 + t) = k$ as an empirical fact, tabulating data for hydrogen, neon, and helium to demonstrate the point; further, they show by tabulated data that this equation does not apply to liquids. Then, by a clear argument of convenience, T is substituted for $273 + t$. In a later chapter, after the consideration of Avogadro's principle, it is demonstrated that $k = Rn$, where R is a simple proportionality constant, whose dimensions depend upon the units used for the other symbols. The awkward equation involving pressure and temperature correction terms to be applied to gas volume never rears its unintelligible head.

Each chapter is headed by a brief introductory statement and epitomized by a summary at the end. The problems after each chapter are pertinent and of graded difficulty. Answers are not given for any of the problems.

This text is notable for the absence of the usual historical treatment. Aristotle's name is not maligned; the Galilean myth about the Leaning Tower of Pisa, the unequal weights, and the dawning of the day of experimental science is, fortunately, not repeated here. However, the drama behind Cannizzaro's pronouncement of Avogadro's principle, the tremendous insight possessed by such men as Dalton, the eccentricities of Cavendish, Kekulé's fireside dreams, and other similar interesting, not to say inspiring, episodes are not even hinted at in this text. The authors explain this lack by stating that such incidents can neither be properly described nor fully grasped without a great deal of preparation. The disagreement between authors and reviewer can be simply stated: Can the facts and principles of chemistry be understood and appreciated by a student who knows little of the intellectual processes and physical struggles that preceded their discovery and formulation? We need men who doubt the principles, but not the facts, of our science; and the earlier we begin to impart this desired attitude in the training of such men, the better. The judicial use of the historical method is a great aid to this end.

Descriptive chemistry organized according to elements in groups is not present. The authors have delightfully chosen to discuss descriptive chemistry as ordered to phenomenon and process. Thus, a single chapter treats of the refining of the common metals from their ores. General principles, similarities and differences are emphasized to the advantage of the student with no total diminution of the usual concepts covered in an elementary text. The authors have been very free with actual examples when discussing their phenomena and processes.

This text contains no clear statement of the Brönsted theory. Acids are defined as substances which, when added to water, produce an acid solution. Acid solutions are defined as sour-tasting liquids which have the ability to turn blue litmus red. No reference was found to the concept of stable and unstable n/p ratios in the discussion of radioactivity. The reader never gets an answer of any sort to the legitimate question, "Why is radioactivity?" The diagram showing the tracks produced in a Wilson cloud chamber is misleading, as is the diagram accompanying the discussion on vapor pressure.

All in all, if you are looking for a text that is different, and if you think that elementary chemistry can best be taught without reference to a historical background, this text merits your critical examination and may earn your approval.

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● EXPERIMENTAL NUCLEONICS

***Ernst Bleuler*, Professor of Physics, Purdue, and *George J. Goldsmith*, Instructor in Physics, Purdue. Rinehart & Co., Inc., New York, 1952. xv + 393 pp. Illustrated. 15.5 × 24 cm. $6.50.**

THIS book consists of an introduction of three chapters on Radiation Protection, Laboratory Equipment, and Preparation of Sources, followed by three parts entitled General, Chemical, and Physical Techniques describing experiments on twenty-four different items, ranging from fundamental studies of the Geiger-Müller counter and other detecting devices, through various activation and radiochemical techniques and concluding with some of the more involved physical phenomena such as coincidence measurements and cosmic rays. An appendix contains the usual constants and tables as well as a statement of radioactivity tolerance levels. Adequate author and subject indexes are included and a Segré chart of nuclei (1948) is contained in a back cover pocket. The book is pleasing in appearance and well constructed in matters such as binding, type, headings, figures, etc.

This book is considerably more than a manual of laboratory directions, since the directions for each experimental item are preceded by a detailed discussion of the principles involved, frequently occupying several times the space of the actual experiment. This material cannot and does not pretend to substitute for a first text in the field, but in all cases examined it is thorough and well illustrated by figures and tables. The actual experiments usually begin with a careful list or description of the mate-

rials and equipment needed, followed by any preliminary or preparation instructions. Then the procedure is given in numbered steps and finally instructions are given on the evaluation and reporting of the data. References for supplementary information are usually given at the end of each experiment. So far as the experience of the reviewer extends, the experimental directions are more than adequate and should give manageable results, and yet the work is not oversimplified or remote from actual practice.

The part entitled Chemical Techniques contains nine experiments which, together with material from the preceding general section, offer adequate material for instruction of chemists. However, some of the descriptive material in the first section might be a little beyond the training and experience of the average graduate student in chemistry, and is certainly too advanced for students in still more remote fields such as biology. Some of the experiments require equipment or materials which would be available only at a laboratory having a strong research program in the field, and like most advanced laboratory books, this one is somewhat tied to the particular equipment described. The experiments offered make excellent use of the natural activities and those which can be induced by a small Ra-Be neutron source. A few experiments require cyclotron bombardment, and one or two require activities distributed by the A.E.C. It would seem that the latter source has not been exploited as fully as would have been desirable from the viewpoint of institutions without a cyclotron or equivalent device. However, such shortcomings are almost unavoidable, and have been adequately minimized through the variety of the offering, which includes many significant experiments which can be performed with relatively simple facilities. This book should certainly be of great value for either formal or informal training in experimental nucleonics.

RUSSELL R. WILLIAMS, JR.

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● PRESSURE-VOLUME-TEMPERATURE RELATIONSHIPS OF ORGANIC COMPOUNDS

Compiled and Developed by *Robert R. Dreisbach*, The Dow Chemical Co., Midland, Michigan. Third edition. Handbook Publishers, Inc., Sandusky, Ohio, 1952. xi + 303 pp. 239 full-page P-T tables and several minor tables. 27 × 21 cm. $10.

ORGANIC chemists and chemical engineers may well join with the author in acknowledging "indebtedness to the late Dr. Willard H. Dow...for the wonderful way in which he encouraged pure research that often did not have any foreseeable commercial value." The present volume will never pay in mere book sales revenue for the great outlay which the Dow Company has authorized in the development of tables, charts, and calculation techniques in the vapor pressure-temperature field.

The 239 lithographed tables constitute the main body of numerical data, totaling about 200,000 entries of temperature and vapor-pressure values. Preceding these data are examples, fully worked out, for 21 types of problems encountered in the handling of more or less volatile organic compounds. Foremost in these type problems is the one most useful to the organic laboratory worker: namely, to find a boiling point at a designated pressure when only one P-T value is known— usually the "normal" boiling point at 760 mm.

Although complete precision in solution of such a P-T problem is impossible, the Dow group has classified compounds so elaborately (21 "Cox-Chart" families) that much better results may be obtained than are possible from the various logarithmic graphs, nomographs, slide rules, algebraic equations, etc., in current use. In particular these Dow charts yield decidedly better values than the old stock method of plotting log p against $1/T$ and assuming the validity of a straight-line graph, which ignores variations in heat of vaporization. In general, Dreisbach's data are far more dependable than published P-T data for specific compounds found in handbooks, many of which are now known to be highly erroneous. Striking exception to this deprecation of handbook data is seen, however, in the useful Stull tables (*Ind. & Eng. Chem.* 39, 517 (1947)), which, by the way, also came from the Dow laboratory.

Chemical engineers will be interested in the other types of problems, including estimation of heat of vaporization, compressibility, dt/dP, equation constants, critical temperature, approximate flash point, and vapor pressures at extremely low or high temperatures. An example of the elaboration of detail by small intervals is seen in the 17 pages devoted to the "normal alkyl primary amine family," in which over 13,000 boiling points, at different pressures, are given for amines boiling normally at −10° to +349° C.

Aside from chemical research libraries, where this book may be considered absolutely essential, it should be available as a handbook to college students in laboratory courses of advanced synthetic and qualitative organic chemistry. The reviewer knows of no work remotely comparable with this highly creditable, and well-printed volume.

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● THE PHOSPHATIDES

H. Wittcoff, Head, Product Development Section, General Mills Research Laboratory, Minneapolis. ACS Monograph No. 112. Reinhold Publishing Corp., New York, 1951. xviii + 564 pp. 16.5 × 23.5 cm. $10.

IN CONTRAST to the attention that has been given in recent years to the preparation of monographs on the chemistry and biochemistry of the carbohydrates and proteins, there have been relatively few definitive accounts of the chemistry of the lipides. Therefore, Dr. Wittcoff's monograph, which is devoted to a discussion of the chemistry, biochemistry, and technology of the phosphatides, will almost certainly be well received. It not only provides a modern survey of this segment of lipide chemistry but does so in a scholarly and critical manner. It is hoped that in the future the chemistry of the cerebrosides, which is not considered in the present edition, will be accorded comparable treatment.

Dr. Wittcoff's discussion of the phosphatides is divided into six parts, *i. e.*, I, The Chemistry of the Phosphatides, 140 pages; II, The Analytical Determination of the Phosphatides, 41 pages; III, Phosphatides from Plant Sources, 160 pages; IV, Phosphatides from Animal Sources, 81 pages; V, The Biochemistry and Physiology of the Phosphatides, 141 pages; and VI, The Industrial Aspects of the Phosphatides, 51 pages. In addition to the bibilographies at the end of each part there are provided both author and subject indexes. The literature has been covered through 1949 and some reference is made to papers appearing in 1950.

The author properly opens his treatment of Part I with a discussion of the nomenclature and classification of the lipides, and this excellent and thorough account should be welcomed by all teachers of organic chemistry. The statement on page three that a purely chemical classification of the lipides is not possible is a bit strong and should be modified to limit the statement to current ability. Chapter II is devoted to a consideration of the structure of lecithin and it is here that the author first reveals a sense of humor and a willingness to put nonsense in its proper place. In this excellent chapter, and later in subsequent chapters, the author occasionally, but not universally, employs the convention of placing a formal positive charge on the phosphorus atom present in phosphate esters. While there is no doubt as to the validity of this practice, *cf.*, L. Pauling, *J. Am. Chem. Soc.*, 56, 361 (1952), it would have been helpful to comment upon the basis for this convention and to use it consistently. In the third chapter, on the structure of the cephalin phosphatides, the statement made on page 34 in respect to the acylation of β-aminoethanol is awkward, and attention should have been called to the fact that, depending on the reaction conditions,

either *O* or *N* acylation can be achieved. In Chapter IV, on the structure of sphingomyelin, it should be noted that Carter *et al.* obtained an optically active α-benzamidostearic acid by the oxidation of N-benzoylsphingine and not N-benzoylsphingosine, as stated on page 41. On page 44 the double bond in the formula of nervonic acid is printed incorrectly. The structural formula given for betaine in Chapter V, The Structure of the Minor Phosphatides, is not acceptable, particularly in view of the author's comments on pages 12-13. On pages 56, 65, and 83, and possibly elsewhere, the authors uses the generic term "galactolipide." It is the reviewer's opinion that because of the possible presence of other sugars in these substances the generic term "glycolipide" is preferable. The statement on page 64 that the amino group in "cephalin" can be methylated with formaldehyde requires explanation since one might also expect hydroxymethylation. In the discussion of the synthesis of the phosphatides, *i.e.*, Chapter X, the symbols $[M]_D$ and M_D are both used to indicate the molecular rotation. Universal use of the former symbol is desirable. On page 153 the use of the term methylene dimethyl ether as an alternative to methylal is less awkward than the expression used, *i. e.* the formal of methyl alcohol. The discussion in Chapter XII, Determination of Individual Phosphatides and Related Compounds, is excellent; however, the lack of any mention of the use of frontal analysis for the analysis of fatty acid mixtures was somewhat disappointing since this technic is probably one of the most useful for this purpose.

It is the reviewer's opinion that Dr. Wittcoff's book is an outstanding one and there is little doubt that it will be regarded as indispensable to those whose interest may, from time to time, require them to become familiar with some phase of the chemistry of the phospholipides. In fact with the availability of this book and that of Hilditch, "The Chemical Constitution of the Natural Fats," (*cf.* J. CHEM. EDUC., 26, 53 (1949)) it can be said that a modern treatment of a considerable segment of the chemistry of the lipides is available to both the student and the investigator.

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● PROGRESS IN ORGANIC CHEMISTRY. VOLUME I

Edited by *J. W. Cook*, Regius Professor of Chemistry, University of Glasgow and Fellow of University College, London. Academic Press, Inc., New York, 1952. viii + 287 pp. Illustrated. 16 × 25.5 cm. $7.80.

THE stated objective of this volume, written primarily for research workers and advanced students, is to present in a concise but adequate form description of recent developments in selected fields of organic chemistry. The eight subjects discussed in this volume and their reviewers are: Molecular Structure of Strychnine, Brucine and Vomicine, Sir Robert Robinson; Chemistry of Some Heartwood Constituents of Conifers and their Physiological and Taxonomic Significance, H. Erdtman; Photodynamically-Active Natural Pigments, H. H. Brockmann; Chemicals from Petroleum, S. F. Birch; Acetylene Chemistry, B. C. L. Weedon; Drugs Inhibiting Symptomatic Stimulators, F. Bergel and M. W. Parkes; Free Radicals as Intermediates in Organic Reactions, D. H. Hey; Starch and Its Products of Amylolytic Degradation, I. A. Preece.

The reviews are of the same type as are to be found in *Chemical Reviews*, are prepared by active workers in the field, and are authoritative. The shortest review (19 pages) is that by Brockmann; the longest (51 pages) by Birch. The editor notes that comprehensive accounts of advances in every phase of organic chemistry are apt to take so long to prepare that they tend to become somewhat out of date even before they are published. This volume is no exception despite its more limited objective. Numerous citations to the original literature are provided with each subject but, aside from a number of references given as an addendum or obviously added after the main portion of the article had been written, references to publications after 1948 are relatively few. In fact, in the chapter on Free Radicals as Intermediates in Organic Reactions the only reference after 1948 is to a book! The typography is good; the binding seems adequate and the price high.

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● FUNDAMENTALS OF SEMIMICRO QUALITATIVE ANALYSIS

Erwin B. Kelsey, Associate Professor of Chemistry, Yale University, and _Harold G. Dietrich_, Assistant Professor of Chemistry, Yale. Revised edition. The Macmillan Co., New York, 1951. viii + 328 pp. 15 figs. 8 tables. 14 × 20.5 cm. $4.

IN THIS revised edition the authors have made many improvements over their first edition. The large print of the previous volume has given way to smaller but still readable type and the saving in space has made it possible to incorporate a great deal of additional descriptive material in an equal number of pages.

The first half of the book presents and discusses capably the fundamental theory required for an understanding of qualitative analysis. This section includes chapters on the nature of substances, solutions, ionization, protolytic equilibria, the formation and dissolution of precipitates, complex ions, and principles of oxidation-reduction.

The second half of the text describes and outlines the analytical procedure for both cation and anion analysis, with about ten per cent of the book devoted to the latter. The system of cation analysis follows the conventional qualitative groupings of the elements except that the amphoteric elements Al, Zn, and Cr and the other elements precipitated as sulfides from basic solution are separated together in the group precipitation by the simultaneous use of ammonia with hydrogen sulfide.

Each group separation is preceded by a listing of the applicable descriptive chemistry of each element in the group. In addition, a set of good preliminary experiments has been included to help the student understand the separation. Following the outline of the analysis of the group and notes on this analysis there is an excellent section on the theory of the analysis and some pertinent exercises. Equations for the net reactions are used throughout.

The text gives explicit directions for the semimicro manipulation required in the procedures and ends with an appendix which includes a discussion of exponents and logarithms as well as tables of constants.

The authors have written a very usable qualitative analysis text which can be highly recommended for consideration to anyone teaching the subject.

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● LABORATORY EXPERIMENTS IN THE PHYSICAL SCIENCES

Anton Postl, Assistant Professor of Science, Oregon College of Education, Monmouth, Oregon. Burgess Publishing Co., Minneapolis, 1951. v + 72 pp. Illustrated. 21 × 27.5 cm. $1.50.

THIS is a laboratory manual for use in a general physical science course. It contains 26 experiments designed for a 2 or 2½ hour period. Necessary supplies include a modest amount of apparatus and chemicals and some maps. Graph paper is supplied in the manual.

Some experiments are descriptive, most are quantitative. Three questions follow each experiment. These emphasize the significance of certain operations of the principles being investigated. The subject matter of the experiments is divided among astronomy (2), chemistry (6), geology (6), metecrology (2), and physics (10).

The experiments are simple but significant and they are clearly explained. Diagrams are given where needed and, in a few cases, the explanation or arrangement of the apparatus is referred to the instructor. The manual is the spiral binding, expandable type, but is not a "fill-in." Experiments are to be written up according to a suggested form on the right hand page which is blank.

This should be a useful laboratory manual for a class which has a 2- to 3-hour lab period. Many of the experiments could be extended over more than a single period if only one hour is available.

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● LES THÉORIES ÉLECTRONIQUES DE LA CHIMIE ORGANIQUE

***Bernard Pullman* and *Mme. Alberte Pullman*, Institute of Radium, Paris. Preface by *Louis de Broglie*, Secretary of the Academy of Sciences. Masson et Cie, Paris, 1952. 665 pp. 170 figs. 17 × 25.5 cm. 2800 fr.**

A ROUGH idea of the extent to which the whole broad field of molecular structure is covered in this important book can be gained from the following list of the titles of the ten chapters: The Foundations of Theoretical Chemistry; The Atom; The Chemical Bond; The General Methods for the Study of Conjugated Molecules; Resonance Energy and Its Principal Applications; Bond Order and Its Physicochemical Significance; Distribution of Electric Charge and Dipole Moments; Electronic Spectra and Color; The Diamagnetism of Aromatic Compounds; and Molecular Diagrams and Chemical Reactivity.

The book begins with a brief introduction to quantum mechanics, after which the problem of valence is treated by both the valence-bond and the molecular-orbital methods. In this discussion, the relations of the two methods to each other are clearly explained, and the reader's attention is called to the limitations of each treatment. The mathematical procedures by which resonance energies, charge distributions, bond orders, etc., etc., are calculated are described in detail and illustrated with many numerical examples. Moreover, the values calculated for the energies of all the π molecular orbitals in a rather large number of unsaturated and aromatic hydrocarbons are collected in a useful appendix. This book is, in fact, particularly valuable in that it is one of the few places in which a novice can at present find an orderly and complete presentation of all the material that is necessary for an adequate understanding of the contemporary literature on the quantum-mechanical treatment of valence.

After devoting approximately the first half of the book to these essential mathematical details, the authors then turn their attention to the more qualitative and more descriptive applications of the theory thus developed. As is only natural, considerable emphasis is placed upon the concepts of bond order (indice de liaison), of free-valence number (indice de valence libre), and of molecular diagrams (diagrammes moléculaires), which have been so extensively developed by the Drs. Pullman and their numerous collaborators, as well as by the closely associated English school. Since these concepts seem not to have received in America as much attention as they deserve, it may be hoped that this book will do much to correct the present unfortunate neglect.

In view of the eminence of the authors in the field of molecular structure, the reader can of course expect the book to be authoritative. In this expectation he will not be disappointed. He might, to be sure, regret that in numerous instances the distinction between theory and fact has not been more clearly and more positively drawn; or he might wish that less space had been devoted to the computation of the precise numerical values of quantities which cannot be measured experimentally, either because the substances to which they refer are unknown or because the experimental significance of the quantities themselves (*e. g.*, the free-valence number) has not been sufficiently precisely defined. However, such defects as these, if indeed they be defects, vary in importance with the prejudices of the individual readers and in any event they do not seriously detract from the value of this excellent contribution to the scientific literature.

The book has been attractively printed, but it is possible that most of those American readers who can afford its high price in the first place would prefer to pay a few cents more to have it bound, and especially to have its pages cut. The proofreading has in general been quite satisfactory so that there are few errors, if any, which are likely to cause trouble. One of the more serious such errors, for example, is a rather trivial one on pages 156 and 157, where the method specified in Figure 16 for numbering the carbon atoms in the naphthalene molecule is inconsistent with the set of canonical structures listed in Table III. A still less important error occurs on page 510 where the benzenoid rings in structures CVII and CVIII should obviously be replaced by quinoid ones. Moreover, it may be wondered whether the printer ran out of lower-case e's, for in about the last fifty pages this particular letter is missing several dozen times. Finally, attention may here be called to a matter of nomenclature which may perhaps be customary in France, but which is likely to cause some confusion with an English-speaking reader: throughout Chapter VIII, any ultraviolet absorption band which is described as "the most distant" (la plus lointaine) is always to be understood as the one *closest* to the visible.

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● ENCYCLOPEDIA OF CHEMICAL REACTIONS. VOLUME IV

***C. A. Jacobson*, Professor of Chemistry, Emeritus, West Virginia University, Compiler and Editor. Reinhold Publishing Corp., New York, 1951. 790 pp. 16 × 23.5 cm. $14.**

THIS book continues the series, dealing with the reactions of iron, lanthanum, lead, lithium, magnesium, manganese, mercury, molybdenum, and neodymium. The format and arrangement is, of course, similar to those of the earlier volumes. The value of this series to chemists has been mentioned in earlier reviews.

● CONDENSED REVIEW OF PHARMACY

***George W. Fiero*, Esso Standard Oil Company. Seventh edition. John Wiley & Sons, Inc., New York, 1952. 122 pp. 23.5 × 16 cm. $3.25.**

THIS is a handbook rather than a review. Some tables and lists of interest to chemists are those of the organic and inorganic chemicals in the U. S. P. and the N. F.; the common names of official drugs. Part V on Elementary Chemistry condenses it all—organic and inorganic—into five pages!

ERRATUM

IN THE review of the seventh edition of Lowy, Harrow, and Apfelbaum's "Introduction to Organic Chemistry" on page 530 of the October issue, the price of this book is given as $5. The publishers have informed us that the price has now been increased to $5.50.

ANNUAL INDEX—JOURNAL OF CHEMICAL EDUCATION

VOLUME 29, 1952

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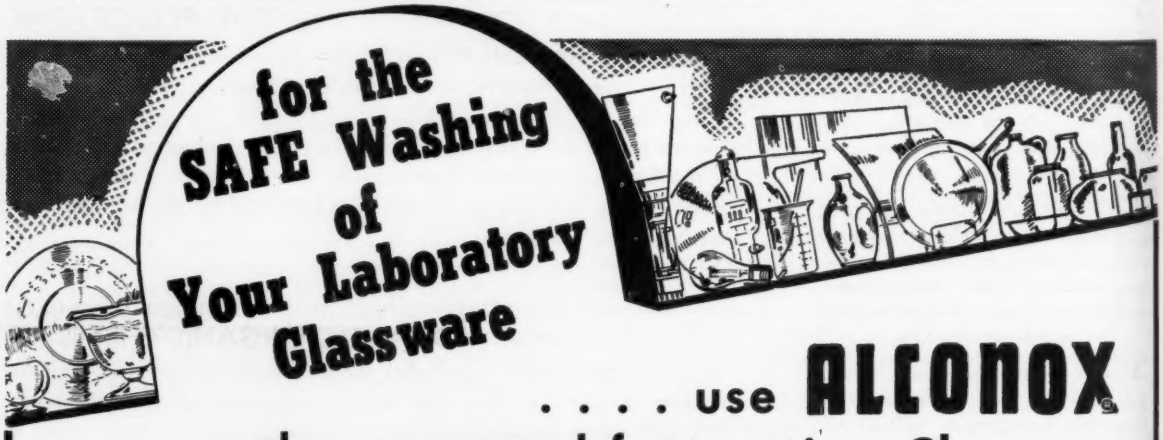

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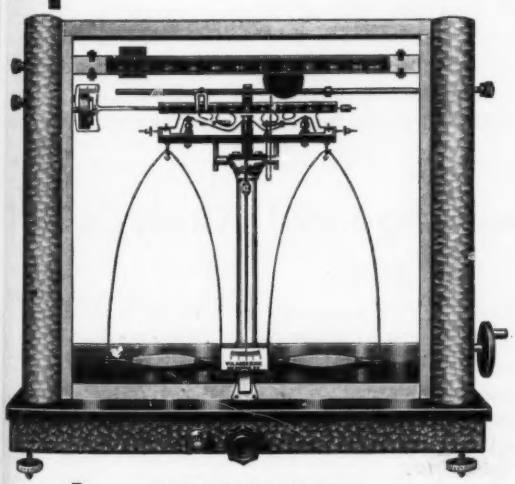

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Out of the Editor's Basket

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Award for Service

The administration and the Board of Trustees of the University of Pittsburgh have presented Dr. Alexander Silverman with a silver medallion for the years of valuable service which he has rendered the institution. He has served the University of Pittsburgh during a 50-year period. In 1901 he was undergraduate teaching assistant in chemistry. In 1905 he joined the full time teaching staff of the Chemistry Department, and from 1918 to 1951 he was head of the department.

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A multicolumn countercurrent molecular still designed by Dr. S. L. Madorsky of the National Bureau of Standards appears to have significant advantages for the commercial separation of liquids which differ in their molecular weights or vapor pressures but have similar properties otherwise. The columns of the still are arranged in such a way that the condensates move by gravity from column to column in one direction while all the residues move similarly in the opposite direction. Counter-current refluxing with automatic recombination of fractions is thus obtained, and the desired separation of fractions is accomplished in a single operation. Among important possible applications of the new device are the concentration of vitamins from natural sources and the purification and concentration of vegetable oils, animal fats, lubricating oils, and high-boiling petroleum fractions.

Traveling Exhibit

Man's improvement on nature through scientific creation of new materials was the theme of a new UNESCO traveling exhibit which opened in Paris in June. This was the third of a series of exhibits on the popularization of science. The first dealt with physics and astronomy and is now in Venezuela. The second, "Our Senses and the Knowledge of the World" toured through Laos, Vietnam, and Cambodia. The new exhibit contains more than 2000 items made of plastic and more than 500 samples of the new light metals. It goes to Yugoslavia in the fall.

Federal Research Programs

Federal agencies supporting scientific research and development programs by grant or contract with educational and other nonprofit institutions have been asked to supply the National Science Foundation with statistical and fiscal information about their programs for fiscal 1951 and 1952. The Foundation is compiling such information on a continuing basis at the request of the Bureau of the Budget, which

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H_2SO_4 H_3PO_4 HCl HNO_3 H_2CrO_4 Cl_2 KOH $FeCl_3$ H_2O_2 NH_4OH $CH_3(CH_2)_{16}COOH$ HF C_6H_6 CH_3COOH H_2O HCN C_2H_5OH CH_3OH NaOH

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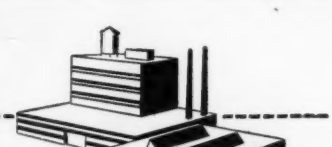

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has gathered similar information on Federal research and development programs in previous years.

The final report, which it is hoped will be available before January 1, 1953, will be of value not only to the Bureau of the Budget and the Congress but to the agencies themselves in the administration and planning of their research and development programs in fiscal 1953 and subsequent years. The information will also be of value to the Foundation in fulfilling its statutory responsibilities with respect to scientific research and its studies concerning the effect of present support and present policies upon research and education in the institutions of the country.

Rare Chemicals Pool

Chemicals prepared in colleges and universities are now being used to facilitate the work of both academic institutions and industry. Chemicals Procurement Co., 550 Fifth Avenue, New York 36, New York, announces the establishment of a rare chemicals pool—with the cooperation of chemistry departments throughout the country. Lists are submitted by these departments to CPC of rare inorganics, metallo-organics, and organics that might be stored and forgotten or thrown away.

Thus industry has access to a hitherto untapped source of hard-to-get and new chemicals, schools—from which a great part of research and development stems.

New Spectrophotometer

The new AO Rapid Scanning Spectrophotometer manufactured by American Optical Co., Instrument Division, Buffalo, New York, is one of the first commercially available kinetic spectrophotometers for the instantaneous display of spectrophotographic curves of various materials through the entire visible range of the spectrum.

It is an unique combination of optical spectrophotometer and electronic indicating device which traces curves at 60 per second on the face of a cathode ray tube against a linear wave-length-per-centage grid. Because of its extreme speed the Rapid Scanning Spectrophotometer is particularly adaptable to the study of rapid color changes, or for handling a large volume of work.

For more detailed study or for permanent records, photographs of the tube face can be made with any of the standard 5-inch oscilloscope cameras. As many as 10 curves may be superimposed in one picture together with zero line, 100% line and wave-length standardizing filter reference. Time lapse photographs offer a convenient way of obtaining a permanent record of color changes in sequence.

An illustrated folder, giving complete details is available from the manufacturer.

Careers in Science

A pamphlet entitled "Your Opportunities in Science" may be had from the National Association of Manufacturers, 14 W. 49th St., New York. This is for high-school students and is a good addition to the increasing literature on vocational guidance, in this day of shortage of recruits for science.

Standard Protein Solution

Pro-Sol, a new product marketed by Standard Scientific Supply Corp., 34 West 4th Street, New York 12, New York., fills a demand for a stable, sterile standard of protein or albumin of definite content to be used by biochemists in clinical and research laboratories.

Pro-Sol is prepared from albumin and put up in sterile, cap-sealed bottles containing 2.5 to 3 cc. each. The solution being sterile will keep indefinitely at refrigerator temperatures. Each lot of a known percentage protein content is determined by the Kjeldahl procedure.

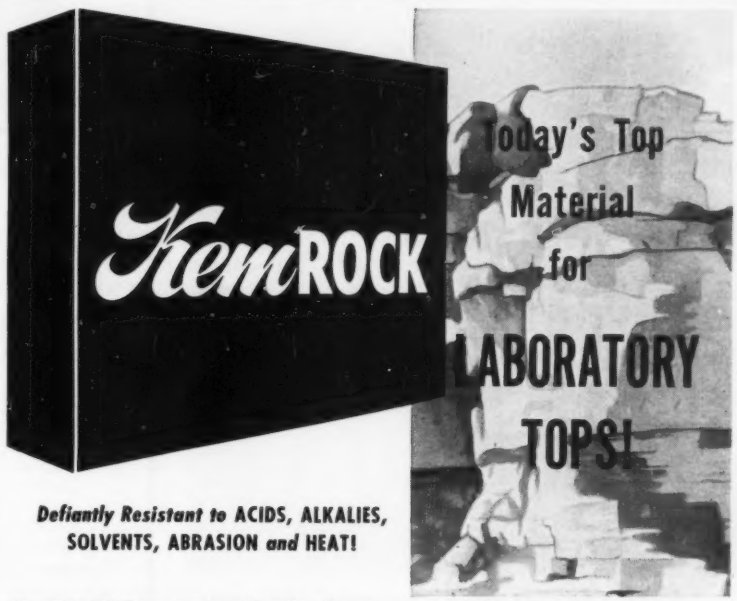
Pro-Sol may be used as standard for any colorimeter, photometric, or Kjeldahl procedure. It is also used for calibration of standard protein curves and as a check on reagents.

New List of Eastman Organic Chemicals Ready

A new and completely revised edition of the Eastman Organic Chemicals Catalog—including an important new section on the nomenclature of organic chemicals—has just been announced by Distillation Products Industries, division of the Eastman Kodak Company.

The list provides detailed information on the more than 3500 organic chemicals supplied by the company together with data on their chemical structure and molecular weight.

Some 256 new chemicals have been added to the Eastman list since the publication of the last catalog and the names of these are listed in a special section. In addition, special lists in the back of the book group various compounds according



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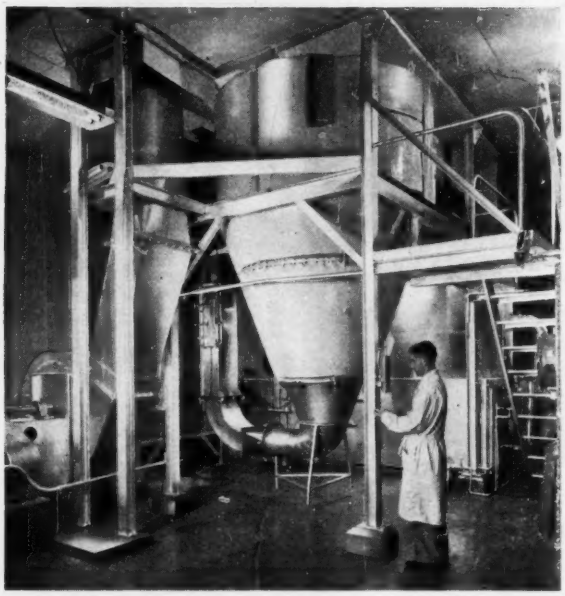

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AC pH Meter.....$215.00

- No batteries
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Just plug it into the 110 volt A.C. current line socket! Complete stability in five minutes means no reading drift!

Your Titrations, too, are easily followed . . . add titrant and watch the immediate change in meter needle position on the BIG scale.

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to their use or structure. Appearing here for the first time is a group of liquids specially prepared for use as solvents for spectrophotometric analysis in the infrared or ultraviolet.

Another major change is a complete revision of nomenclature to correspond to the practices followed by *Chemical Abstracts*. Correlating with this is the new nomenclature section which is available as a special supplement to this catalogue.

List No. 38 of Eastman Organic Chemicals is obtainable on request from the Eastman Organic Chemicals Department, Distillation Products Industries (Division of Eastman Kodak Company), Rochester 3, New York.

Teaching Aids Catalogue

A revised 19-page Teaching Aids Catalogue for 1952–53 is available from the Westinghouse Electric Corporation's School Service Department (Box 2278, Pittsburgh, Pa.). Introducing a section on home lighting pamphlets along with other new classroom aids, the catalogue describes 84 free or low-cost booklets, charts, posters, and other audio-visual aids available to junior and senior high schools.

Glass as a Lubricant

By utilizing glass as a "grease," the production of seamless tubing and solid shapes from the stainless steels and other high melting point alloys and metals has been made possible using the hot extrusion process. In practice, a fiberglass sock is placed over the mandrel at the press. The glass, melting on contact with the hot steel, prevents seizing of the billet and tools and insulates the tools from heat.

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Successful methods of treatment make it more important than ever to find the 150,000 "unknown" cases of tuberculosis—and to find them early.

Mass X-ray campaigns to find TB in time are part of the work your Christmas Seal dollars help support.

Remember, no one can be "cured" until treated . . . and no one can be treated until the disease is discovered.

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New Publication

Latin American students gain a broader knowledge of U. S. student life through a new publication, Student Life. Some 10,000 copies of a Spanish edition have already been distributed in Central and South America. The publication is one of the services of an International News Center, recently established in Atlanta, Georgia, by the National Student Association (NSA). The center also concentrates on informing U. S. students, through college newspapers, of the problems and interests of students in other countries. The NSA is represented on the National Commission by Robert J. Murphy of Chapel Hill, N.C.

Zirconium

A rapid convenient method for purifying zirconium has been developed by National Bureau of Standards, Washington 25, D.C. Purification has until now been difficult, with labs using zirconium in whatever purity they could purchase it. Concentrated sulfuric acid is poured into fairly concentrated aqueous solution of zirconium sulfate or chloride. The resulting precipitate is dissolved in water, reprecipitated several times, leading to zirconium sulfate of high purity.

New Literature

"Burrell 'Unit-Package' Box Muffle Furnaces" is the title of a recently released 4-page bulletin describing a new line of laboratory furnaces for low and high temperature testing operations.

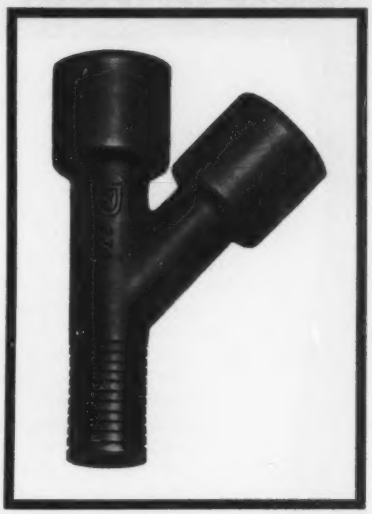
Five different furnace models are described. Detailed information given includes: temperature ranges, features, dimensions and prices. Photographs show net floor-mount and easy-access-panel design. Dimensions and other data are shown in line drawings.

Copies are sent free on request to manufacturer: Burrell Corp. 2223 Fifth Ave., Pittsburgh 19, Pennsylvania. Ask for Burrell Bulletin No. 315.

Laboratory Construction Company announces the publication of a new technical booklet. This 14-page booklet covers three specialized pieces of laboratory apparatus, Kjeldahl Nitrogen Apparatus for the determination of protein, Goldfisch Fat Extraction Apparatus and Crude Fiber Condensers. The booklet contains fifteen laboratory photographs together with information of interest to those concerned with these determinations. The booklet will be sent free upon request. Write Laboratory Construction Co., 1115 Holmes St., Kansas City 6, Missouri.

A new booklet that explains the advantages of using Sanborn equipment for the study and recording of a wide variety of electrical and mechanical phenomena has just been released. It contains 16 pages of pert illustration and pertinent text that describes Sanborn Direct Recording Equipment for industrial and educational users. Entitled "7 Advantages of Sanborn Direct-Writing Recorders," it may be obtained without obligation by writing to Sanborn Company, 38 Osborne St., Cambridge, Mass.

KNIGHT-WARE CHEMICAL EQUIPMENT



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Knight-Ware acid proof pipe and fittings may be used wherever corrosive liquids and gases must be handled. This quality chemical stoneware is not just surface resistant but is physically tough and corrosion proof throughout its entire body. It is resistant to all acids and alkalies, hot or cold, in any concentration.*

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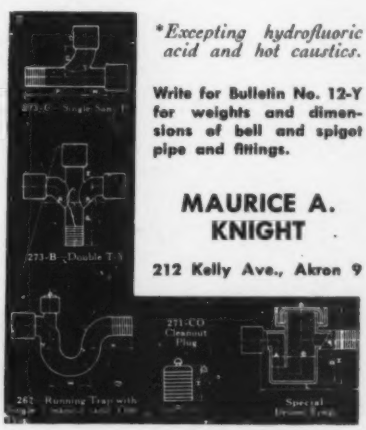

**Excepting hydrofluoric acid and hot caustics.*

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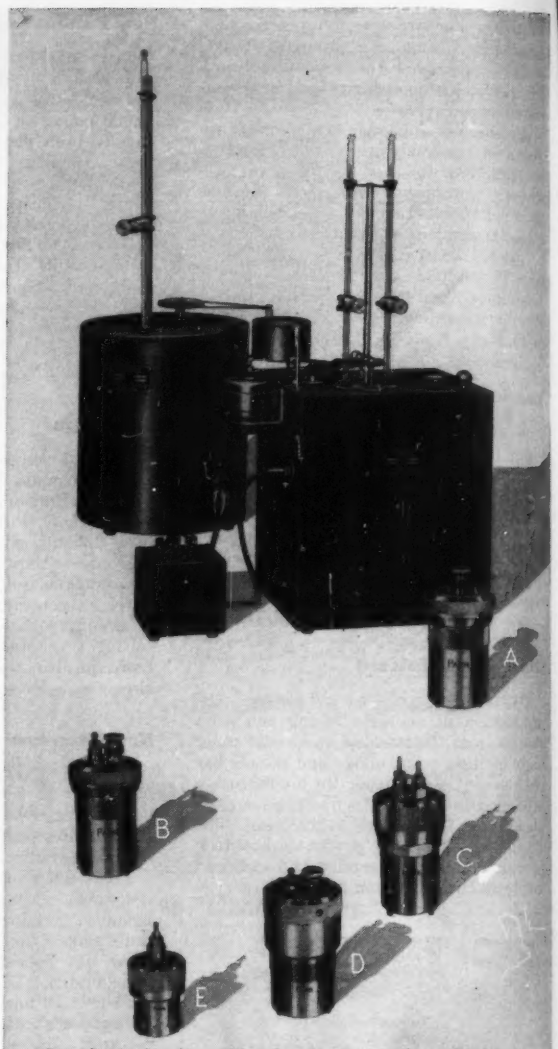

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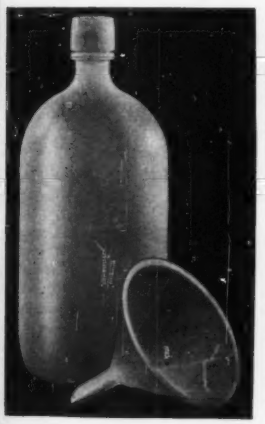

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Cap.	1 oz.	2 oz.	4 oz.	8 oz.	16 oz.
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Each	1.60	4.75	7.50	12.50
Doz.	16.00	47.40	75.00	125.00

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Inside Diam.	Wall Thickness	Less than 50 Feet*	50 to 99 Feet*	100 to 999 Feet*	Over 1000 Feet*
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3/16"	1/16"	.40	.28	.22	.16
1/4"	1/16"	.48	.32	.25	.19
3/8"	1/16"	.52	.38	.32	.26
1/2"	1/16"	.65	.46	.40	.33

* Above prices are per foot

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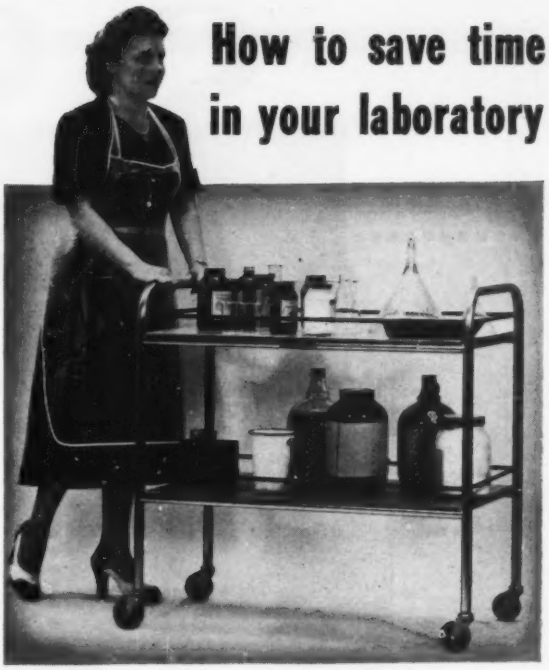

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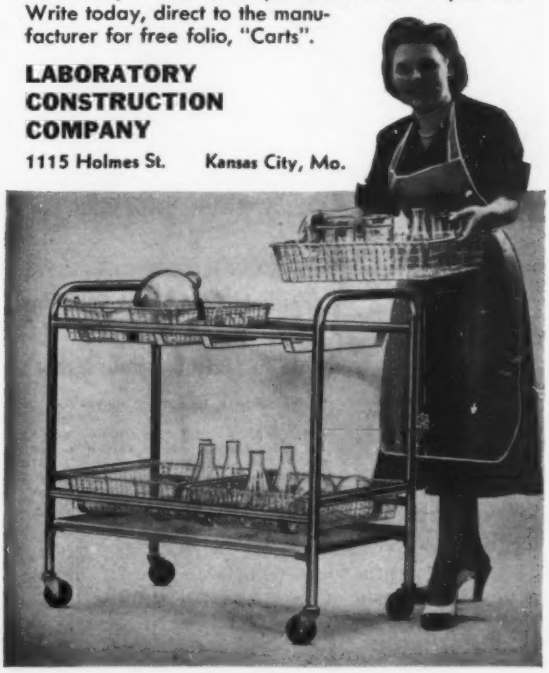

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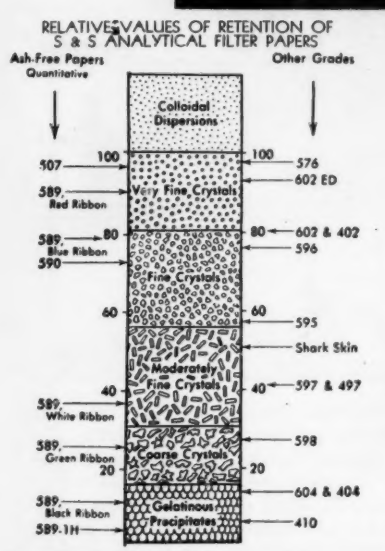

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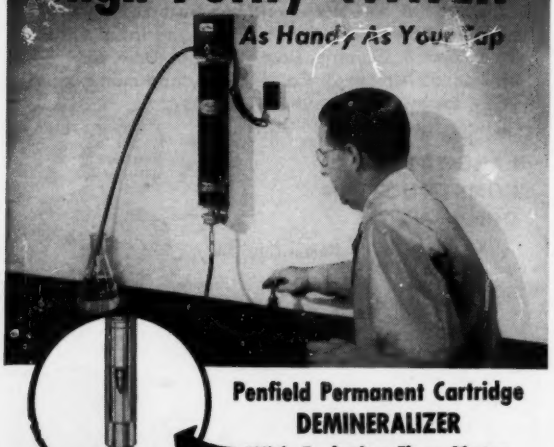

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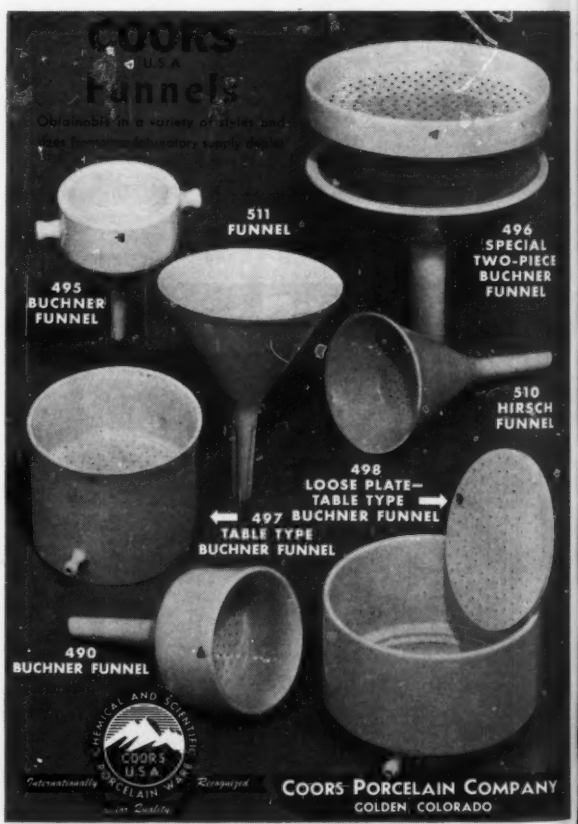

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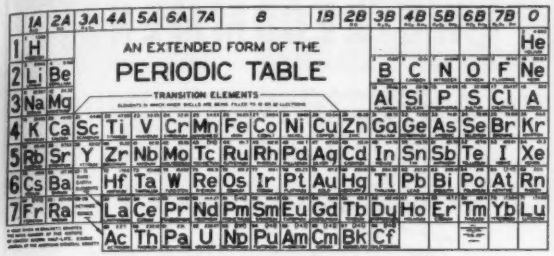

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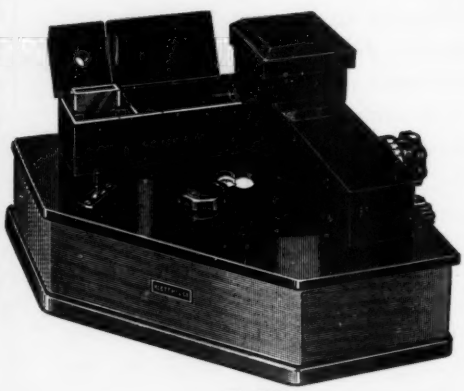

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(1) Ind. Eng. Chem. 25-653 (June, 1933)

(2) Ind. Eng. Chem. 25-1112 (Oct., 1933)

(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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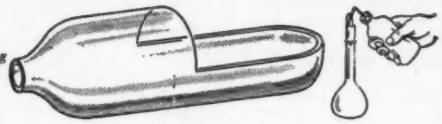

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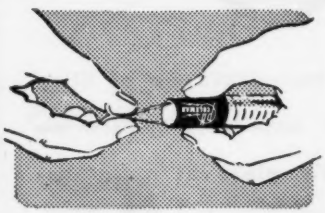

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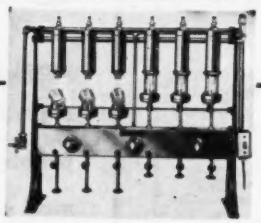

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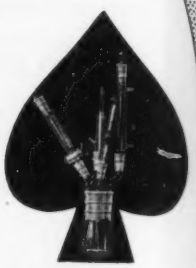

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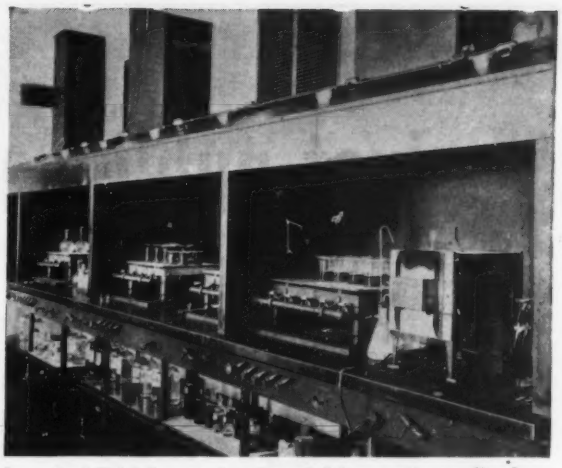

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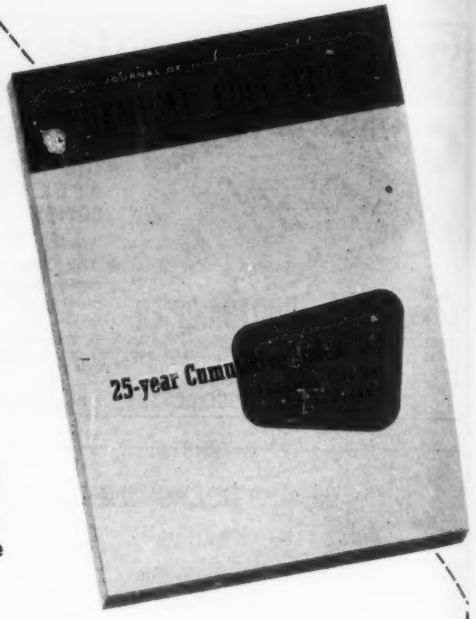

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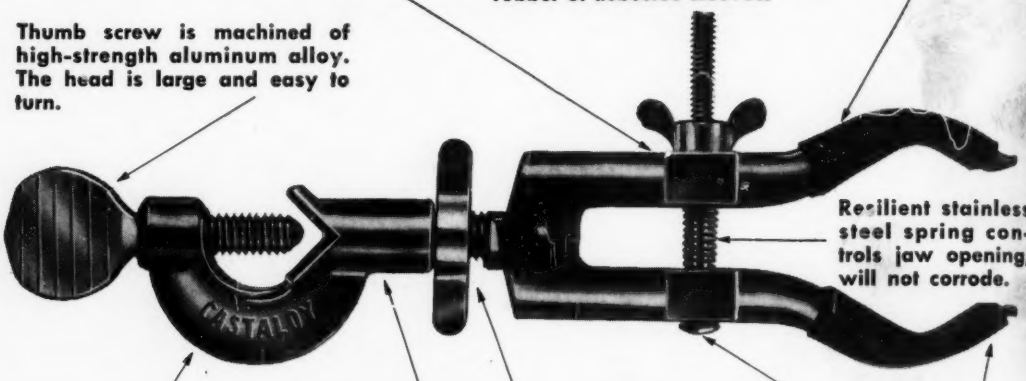
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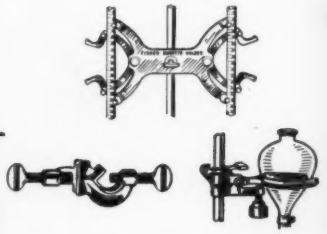

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